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This is a quarterly publication presenting articles covering recent developments in Far Eastern (particularly Japanese) scientific research. It is hoped that these reports (which do not constitute part of the scientific literature) will prove to be of value to scientists by providing items of interest well in advance of the usual scientific publications. The articles are written primarily by members of the staff of ONR

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Cobalamine
Rheology
Polymers
Normal stress
Biopolymers
Crack Propagation
Fiber optics
Rayleigh waves
SAW devices
Electrets
Flow visualization
Turbulence
Japanese marine laboratories
Taiwan biology
Taiwan zoology
Superconductive electronics
Lighter than air
Statistics
Korean standards research

20. Abstract (cont'd)

Tokyo, with certain reports also being contributed by visiting stateside scientists. Occasionally a regional scientist will be invited to submit an article covering his own work, considered to be of special interest.

GUEST CONTRIBUTORS TO THIS ISSUE

Ray Radebaugh is a physicist on the staff of the Cryogenics Division, National Bureau of Standards, Boulder, Colorado. His principal work has been in millikelvin research and on refrigeration and heat transfer technology. He has spent seven months in Japan during four different visits.

Earl F. Skelton, supervisory research physicist at the Naval Research Laboratory, Washington, D.C., visited Japan for the first time in early 1978. During this three-month assignment to ONR Tokyo, he reviewed the field of high pressure science and technology in Japan. His research interests concern studies of the phase transformations in solids with particular emphasis on high transition temperature superconducting materials, lattice dynamics, x-ray crystallography, ultra-high pressure and low temperature technology, x-ray diffraction physics and electronic data processing. As an amateur radio operator Skelton maintains active interest in long range radio communication via satellite and moon-bounce techniques. In addition to his membership in the Naval Research Laboratory Amateur Radio Club he is currently an officer and alternate member of the Board of Directors of AMSAT, an international amateur satellite organization. Skelton is an Associate Professorial Lecturer in Engineering at George Washington University, a Lecturer in the Graduate School and an Associate Member of the Laboratory for High Pressure Science, both in the Department of Chemical Engineering of the University of Maryland.

Marx Brook is Professor and Chairman of the Department of Physics at the New Mexico Institute of Mining and Technology, Socorro, New Mexico. His research interests in atmospheric physics, particularly cloud physics, lightning and weather radar, have involved him in several important research tasks and brought him considerable international recognition. In 1972 he was one of a small number of experts called in to analyze the data on the Apollo 12 manned moon rocket which was struck by lightning on launch. The analysis verified that the lightning stroke was triggered by the rocket. Brook and the Navy have been awarded a patent on his fast scanning radar which is specially designed for meteorological and clutter targets. In addition to research in England (Cambridge and Manchester in 1968-1969), Brook has visited Japan several times since his first trip in 1965. In 1970 he was in Japan for two months as a lecturer sponsored by the Japan Society for the Promotion of Science.

Elliot A. Kearsley, currently on the staff of ONR Tokyo, is on leave from the Polymers Division of the National Bureau of Standards, Gaithersburg, Maryland. His personal researches are centered on the rheology and mechanical properties of materials. He and his colleagues at NBS have developed a model of non-linear viscoelasticity which is widely used to describe the complex behavior of liquids and solids.

Francis A. Richards, presently on the staff of ONR Tokyo, is Professor of Oceanography and Associate Chairman for Research, Department of Oceanography, University of Washington, Seattle. His research interests in chemical oceanography include analysis of sea water, plankton pigments, oxygen deficient and sulfide-bearing environments in the ocean, interrelationships among the branches of oceanography through chemistry. Since 1973 Richards has been Editor of *Deep-Sea Research.* At the invitation of the host governments, he has conducted research at the Instituto Oceanografico, Universidad de Oriente, Cumana, Venezuela, during the summer of 1960 and at the Turkish Naval Office of Hydrography and Navigation in the fall of 1964. Under the sponsorship of the United States-Japan Cooperative Research Program of the National Science Foundation, Richards spent six months in 1970 at the Meteorology Research Institute, Tokyo, and an additional six months at the Research Institute for Food Science, Kyoto University.

Charles W. McCutchen is a physicist at the National Institutes of Health in the Laboratory of Experimental Pathology, Bethesda, Maryland. His researches include lubrication of animal joints, how fish swim and also involved optical diffraction theory, applied optics and hydrodynamics.

Aubrey Gorbman is Professor of Zoology and formerly was Chairman of the Department of Zoology at the University of Washington, Seattle. Some of his research interests dealt with comparative endocrinology and actions of hormones on the nervous system. In 1955 Gorbman was Visiting Professor of Biochemistry at Nagoya University and again in 1960 as Visiting Professor of Zoology at the University of Tokyo.

Theodore Van Duzer is a Professor at the University of California, Berkeley, where he is engaged in teaching and research in solid-state devices and superconductivity. Professor Van Duzer received his B.S. degree in electrical engineering from Rutgers University in 1954, the M.S. degree in engineering from the University of California, Los Angeles, in 1957, and the Ph.D. degree in electrical engineering from the University of California, Berkeley, in 1960. Dr. Van Duzer has published numerous papers on electron devices, is co-author (with S. Ramo and J. R. Whinnery) of Fields and Waves in Communications Electronics, and is author and principal of an educational film, "Wave Velocities, Dispersion, and the W-B Diagram." Dr. Van Duzer is a member of ETA KAPPA NU, TAV BETA PI, and SIGMA XI, and a Fellow of the IEEE.

Seikoh Sakiyama, who received the Bachelor of Science in Physics from Tokyo University of Science, has had considerable industrial experience in laboratory chemistry, electronic instrumentation and quality control methodology. He has been with ONR Tokyo since its establishment in 1975, as a Scientific Affairs Specialist. In addition to Lighter-Than-Air Technology, his scientific interests include computer science, linguistics and energy technology.

Bruce J. McDonald was associated with the Mathematical and Information Sciences Division of ONR Headquarters for ten years prior to his current assignment as Scientific Director of ONR Tokyo. His academic background is in the physical and mathematical sciences and his interests extend to many other areas in engineering and technology. He has resided in Japan since November 1977.

COVER: Designed by Eunice Mohri, with Kanji characters "Tō" and "Kyō" drawn Seikoh Sakiyama, both of ONR Tokyo.

Partial **CONTENTS :**

ULTRALOW-TEMPERATURE PHYSICS IN JAPAN

Ray Radebaugh

INTRODUCTION

Ultralow temperatures are considered here as those temperatures below about 1 K. Rather unique techniques, not common at higher temperatures, are often used in experimental work at these temperatures. Interest in this temperature range began to grow rapidly about ten years ago after the development of the He^3-He^4 dilution refrigerator, which can maintain continuous temperatures of 10 mK or below. Before 1967 only a few low-temperature laboratories had capabilities for millikelvin research. These laboratories generally used adiabatic-demagnetization cryostats, which could not maintain low temperatures continuously and were often cumbersome. Today a majority of low-temperature laboratories have facilities for ultralow-temperature research. These facilities include at least a dilution refrigerator and sometimes a Pomeranchuk refrigerator (solidification of He^3) and/or a nuclear-demagnetization refrigerator to reach temperatures of about 0.5 mK. Dilution refrigerators are available now from a number of commercial sources. The discovery of superfluid He^3 below 2.7 mK in 1971 has created such excitement that many more laboratories are entering the ultralow-temperature regime.

Relative to many other countries, Japan was a late-comer to the ultralow-temperature field. However, they have been very aggressive since entering the field and their progress has been so rapid that they are now on an equal plane with other leading countries. I have had the pleasant opportunity to be in Japan four times between 1970 and 1977, once for four months in 1972. It has been interesting and educational to observe the rapid progress in this period of time. I wish to share here some of the insights I have gained regarding their progress. I will begin by discussing the progress of individual laboratories and finish with a discussion of a highlight for Japanese ultralow-temperature physics – the International Symposium on Physics at Ultralow Temperatures, held in Hakone, Japan, on September 5-9, 1977. Before I discuss some of the individual laboratories, I wish to apologize to those individuals or laboratories which have been unintentionally neglected. Naturally, my discussion of some laboratories will be more detailed than others simply because I have been able to spend more time with them in my visits.

INDIVIDUAL LABORATORIES

PRE-1970

No working dilution refrigerators existed in Japan before 1970. At the Institute for Solid State Physics (ISSP) of the University of Tokyo, Professor T. Sugawara had a He^3 refrigerator for temperatures down to 0.3 K and Professor K. Ono had an adiabatic demagnetization apparatus for temperatures down to about 10 mK. The former was studying the Kondo effect and the latter was looking at nuclear orientation effects in magnetic materials. One or two other laboratories had He^3 refrigerators but the total effort in millikelvin research was rather small in 1970. By this time, dilution refrigerators which could reach 10-20 mK were becoming fairly common in the United States and several European countries.

TOHOKU UNIVERSITY, SENDAI

This university is considered the birth place of low-temperature physics in Japan. In the early 1950's Professor E. Kanda purchased a Collins helium liquifier, which was the starting point for building an excellent

low-temperature physics group at Tohoku University. This university was also the site of the first dilution refrigerator in Japan, built in 1970 by Dr. S. Saito of the Institure for Iron, Steel and other Metals. Because it had a glass still to observe the liquid level, it reached only 0.2 K. Within two years another one was built which reached much lower temperatures. It was used for NMR studies on magnetic linear chain substances. At the same institute, Dr. A. Ohtsubo started building a dilution refrigerator in 1970 to study NMR in very fine copper powders. In the Physics Department of Tohoku University, Professor T. Satoh also began in 1970 to build a dilution refrigerator for specific heat studies on niobium. During my visit to Tohoku University in 1970 I was particularly impressed with the eagerness of this group. I have not visited there since 1970, but through contacts at conferences I have learned that this group now has several working dilution refrigerators. Dr. Saito contributed a significant paper at the recent Hakone conference showing how a magnetic resonant-coupling between He^3 and an antiferromagnetic solid leads to a sudden drop in the Kapitza thermal resistance near the transition temperature of the solid. Professor Satoh is now building a nuclear demagnetization refrigerator, which is probably the first in Japan. It is to be precooled with a very new dilution refrigerator/Pomeranchuk refrigerator combination using He^4 circulation. A team in Leiden, of which Professor Satoh was a part, developed this combination for temperatures down to 2 mK and reported on this at Hakone. This refrigerator is to be used for studies of superfluid He^3

UNIVERSITY OF TOKYO, HONGO CAMPUS

During the LT 12 conference at Kyoto in 1970, I had the pleasure of meeting Professor K. Nagamine of the Physics Department, University of Tokyo. He had been doing research in high energy physics and had just become interested in the effects of nuclear orientation in such experiments. He and his graduate students were beginning to build a dilution refrigerator in order to cool various nuclear targets and bring about nuclear orientation. Professor Nagamine is well known for his work in high energy physics, but at that time he was just beginning to learn about the special techniques used in millikelvin research. Because it had so much to offer to high energy physics, he was eager to learn more about this relatively new field. During my 1970 and 1972 visits Professor Nagamine arranged many meetings between the two of us to discuss low-temperature techniques. I remember discussing such techniques with him often over dinner or tea in some Roppongi coffee house. He was never afraid to ask questions and he soon reached the stage where I could not come up with answers. In an attempt to answer his questions I found that I was learning as much as Professor Nagamine. This humble behavior of asking many questions is typical of most Japanese scientists.

The ability to ask questions, coupled with an aggressive approach in arranging visits and conferences with sicentists of other countries, appears to be a major reason for the rapid progress of the Japanese in ultralow-temperature physics. Their remote location warrants such an aggressive approach. Professor Nagamine is now one of the world's experts in the application of low temperatures to high energy physics. He has spent the last several years working on the Berkeley and Vancouver accelerators as part of a Japanese team using nuclear orientation techniques in high energy physics.

HIGH ENERGY PHYSICS RESEARCH INSTITUTE, TSUKUBA SCIENCE CITY

Though I have not visited here, I have learned that Professor A. Masaike is doing experiments on polarized targets. He was the first in Japan to build a He^3 refrigerator for polarized targets and now has a horizontal dilution refrigerator, similar to those at CERN, which can cool targets to 30 mK.

INSTITUTE FOR SOLID STATE PHYSICS (ISSP), UNIVERSITY OF TOKYO

In 1972 I had the pleasure of working for four months at ISSP in Roppongi, Tokyo, with Professor H. Nagano and his associates, Drs. Y. Oda and G. Fujii. Professor Nagano had arranged the visit through the Japan Society for the Promotion of Science. At that time they had just finished a dilution refrigerator which reached about 20 mK. It was to be used for studies of superconducting transition-temperatures as a function of pressure.

These people also asked many questions and often our discussions would go well into the night hours before we realized it was time for supper. Since their start in ultralow temperatures back in 1972, this group has now advanced to the point of being one of the leading groups in the world. They now have two newer dilution refrigerators operating near 10 mK. One of these is a precooling device for a Pomeranchuk refrigerator which reaches 1.1 mK. They have been establishing a temperature scale down to 1.1 mK using a La-diluted CMN thermometer calibrated against superconducting fixed points. They have then transferred their measurements to the He^3 melting curve. Previously there had been considerable disagreement over the temperature of the He^3 melting curve but after the paper by Fujii, Oda, Kosuge and Nagano was given at the Hakone conference, there no longer is much uncertainty. Their work was praised publicly at the conference for its excellence and for filling an important need of experimentalists in ultralow-temperature physics.

OSAKA CITY UNIVERSITY

At Osaka City University Professor T. Shigi, of the Physics Department, heads another energetic group involved in ultralow temperatures. They, too, have made great strides since 1970. At that time they were just starting construction of a dilution refrigerator to allow them to pursue research in this newly accessible region. Professor Shigi and his graduate students have been very eager to arrange lectures and to ask questions of visiting scientists. At the Hakone conference it was interesting to see Professor Shigi and his students fan out, each approaching a different person to gather the very latest news and ideas from that source. Professor Shigi's group was the first in Japan to build a Pomeranchuk refrigerator. There were very few other such refrigerators in the world when theirs was working in 1974. They are now using it to study properties of He^3, including the superfluid phases and solid He^3. In the rush to study superfluid He^3, Japan is not being left behind. Professor Shigi is considered a leader in ultralow-temperature physics in Japan.

THEORETICAL WORK

The Japanese have always been noted for their excellence in theoretical physics. The ultralow-temperature regime is no exception. Professor T. Soda, now at Tsukuba University, had made predictions about He^3 becoming a superfluid. Now that it has been discovered, he and many other Japanese theoreticians are actively involved in explaining its behavior and properties. Six theoretical papers on superfluid He^3 were given by Japanese scientists at the Hakone conference.

FUNDING

The heavy emphasis on theoretical work in Japan may have been a result of funding situations. In most cases theoretical work is less expensive than experimental work. A tight funding situation for experimental work was particularly obvious in 1970 and 1972. Many of the laboratories had a foundry-like atmosphere and were badly in need of clean-up and painting. The laboratory equipment was often quite old. Except for the University of Tohuku, money was not available much before 1970 to purchase Collins helium liquifiers from abroad. Japan owes much to Professor H. Nagano of ISSP who designed and built many of Japan's early helium liquifiers. These allowed other universities to get into experimental low-temperature physics at an early stage. The funding situation for experimental work now appears to be more comparable with other countries. Many of the laboratories are now freshly painted and contain enough modern equipment to make numerous visitors envious.

INTERNATIONAL SYMPOSIUM ON PHYSICS AT ULTRALOW TEMPERATURES

This symposium was held at the Hakone Kanko Hotel overlooking Lake Ashi in the beautiful mountainside area of Hakone. Early-morning risers could see Mt. Fuji before clouds usually obscured it later in the day. The date of the symposium was September 5-9, 1977. The fact that this symposium was held in Japan speaks highly of the Japanese reputation and position in the field of ultralow-temperature physics. Professor T. Sugawara of

ISSP was instrumental in organizing this symposium, the first of its type, and served as the chairman. Professor T. Ohtsuka of Tohoku University was program chairman and all the details were efficiently handled by the secretary, Professor S. Nakajima of ISSP. The symposium had an international advisory committee and was sponsored by The Japan Society of the Promotion of Science, The Cryogenic Association of Japan, The Physical Society of Japan, and The International Institute of Refrigeration. There were about 114 people at the symposium with nearly all countries that are active in ultralow temperatures represented. About 78 were from Japan. There were nine sessions at the symposium – three on superfluid He^3, two on ULT (ultralow temperature) techniques, one on solid He^3, one on Kapitza resistance and thermometry, one on nuclear cooling, and a final summary session. These will be discussed separately below.

SUPERFLUID He^3

An excellent introductory talk was given by D.M. Lee of Cornell, one of the co-discoverers of superfluid He^3. Since the discovery of superfluid He^3 in 1971, a large number of laboratories have moved into this field. This subject occupied over a third of the conference and many of the other papers on techniques discussed apparatus to be used with superfluid He^3. This interest in superfluid He^3 is understandable when one realizes that it is the most "super" of the superfluids. The other two superfluids are He^4 and superfluid electrons or superconductivity. Superfluid He^4 is rather humdrum compared with superfluid He^3. Whereas the superfluid states of He^4 and of electrons have only one phase and are nonmagnetic, superfluid He^3 has three phases and is magnetic. For pressures near the melting curve the A phase occurs below 2.7 mK and the B phase occurs below 2.1 mK. In the presence of a magnetic field the A_1 phase occurs in a narrow region between the A phase and the normal liquid. These phases occur because the He^3 atoms can pair in different ways. In forming a superconductor, electrons pair up only with electrons of opposite spin. The resultant pair is nonmagnetic and spatially symmetric. In He^3 the atoms pair up with other atoms which have the nuclear spin in the same direction. Because of the Fermi exclusion principle, the pair must then be spherically asymmetric. The He^3 pair then has characteristic directions associated with its magnetic axis and with its axis of asymmetry. Well-established quantum laws show that these two axes can be oriented in three possible ways. The A and B phases are characterized by various combinations of these configurations. It is therefore evident that superfluid He^3 is a very complex substance which will require many years to be understood in detail.

Other papers at this conference discussed experiments and theories aimed at understanding the structure of superfluid He^3. Because boundary conditions affect the orientation of the magnetic and asymmetry axes, textural effects occur in any finite volume of He^3. Such behavior leads to wave-like motion called solitons. The textural behavior of He^3 in various geometries and the behavior of solitons seemed to be the dominant subjects of interest at the meeting. There was also some interest in the possible ferromagnetic behavior of the surface of superfluid He^3

SOLID He^3

Professor E.D. Adams of the University of Florida gave an interesting talk on the latest research on solid He^3. The interest here is on the nature of the magnetic ordering which occurs at about 1.2 mK. This is a nuclear ordering and there has been speculation that it is ferromagnetic, weakly ferromagnetic, antiferromagnetic, or a spin-flop state. Any of these are exciting since it is the first case of a cooperative magnetic ordering on a nuclear scale. Evidence presented at this conference in papers by Adams, Goodkind and Morii suggest that the ordered state is antiferromagnetic at low magnetic fields but transforms to a spin-flop state at higher fields.

KAPITZA RESISTANCE

I presented a paper (co-authored with J.D. Siegwarth of NBS) on "The Effect of Heat Treatment and Impurities on the Kapitza Resistance of Copper below 0.2 K." In this paper we pointed out that the best temperature range to study the basic phonon heat conduction process between a solid and liquid He^3 or He^4 is

in the range of 20 mK to 200 mK. Above and below this temperature additional parallel heat transfer mechanisms occur which make it difficult to measure and understand the most basic process. Even in the range 20 mK to 200 mK we showed how the presence of dislocations and impurities can give rise to an enhanced heat transfer by the interaction of surface phonons with these defects. The effect of impurities had not been considered previously. Two other papers on Kapitza resistance were concerned with a magnetic coupling between the solid and He^3 liquid. Saito showed how the Kapitza resistance changes abruptly when the solid orders antiferromagnetically. Such behavior implies a resonance coupling.

ULT TECHNIQUES

The excitement in these sessions centered around the talk by Dr. G. Frossati, Centre de Recherches sur les Tres Basses Temperatures, Grenoble, France, in which he reported a new record low temperature of 2.0 mK for a continuously-operating dilution refrigerator. For several years about 6 mK was the lowest temperature achieved. The limit was set by the high Kapitza resistance of the heat exchangers. During my 1972 visit to Japan I found a Japanese company which had just begun to make and sell submicron silver powder. They gave me a free sample of this fine powder and at NBS/Boulder we measured the Kapitza resistance between it and a dilute He^3-He^4 solution. The very large surface area of the powder resulted in a very low Kapitza resistance per unit volume of powder. The work was reported at the 5th International Cryogenic Engineering Conference in 1974 at Kyoto. Frossati then used this 700 Å diameter silver powder manufactured by the Japanese company, along with some coarser French-made silver powder, to make the heat exchangers for his successful dilution refrigerator. A low temperature of 2 mK is nearly as low as those reached by Pomeranchuk refrigerators. That may have a significant influence on the further development and use of the Pomeranchuk refrigerator.

Other papers in this session discussed some new variants of dilution refrigerators such as the type where He^4 is circulated instead of He^3. R. de Bruyn Ouboter of Leiden discussed their progress on the He^4 circulation dilution refrigerator developed by them. They now reach 8 mK with it. The advantage of such a refrigerator is that it can be pressurized to 25 atm to cause further cooling to 2 mK by solidifying the He^3. Such a combination dilution refrigerator-Pomeranchuk refrigerator is now being built in Japan by Professor T. Satoh at Tohoku University. Professor Satoh gave a progress report on this machine which is used to precool a nuclear demagnetization refrigerator. Papers by R. Rosenbaum of Tel-Aviv University and G. Schumacher of Grenoble discussed the advantage of using a second mixing chamber on a dilution refrigerator to achieve lower temperatures. Dilution refrigerators with quite conventional heat exchangers can reach 3-5 mK in a second mixing chamber.

NUCLEAR DEMAGNETIZATION

O. Lounasmaa of Helsinki gave a general review of this subject. There are now 25 such refrigerators operating or under construction throughout the world. All but about one of these is for cooling of liquid He^3 to study the superfluid properties. The one exception is at Leiden for studies of nuclear orientation effects in high energy physics experiments. Presently He^3 has been cooled to about 0.5 mK with nuclear demagnetization devices. Several papers gave progress reports on these refrigerators.

SUMMARY TALK

Professor A. Leggett of the University of Sussex gave an excellent summary talk for the conference. Instead of an actual summary, the talk was more along the lines of "where do we go from here." His ideas for new physics were in the areas of (1) p-wave superconductivity, (2) superfluidity of He^3 in He^3-He^4 mixtures, (3) superfluid pure He^3, (4) nuclear magnetic-ordering of solid He^3, and (5) nuclear ordering in other solids. In the area of superfluid He^3, he discussed the possibility of ferromagnetic ordering in superfluid He^3. If it occurs, it would be the first liquid ferromagnet.

Papers at this conference are to be published in a volume of the Journal of the Physical Society of Japan in early 1978.

OUTLOOK

The Hakone conference was more than a high point for ultralow-temperature physics in Japan. It certainly served to recognize the progress and accomplishments of the Japanese scientists, but it also offered an opportunity for the Japanese to enhance their progress even more. In the traditional hospitable Japanese manner, foreign scientists were invited to visit many of the individual laboratories. At the end of the conference it was a common sight to see foreign visitors being escorted to the train station by the Japanese for the first leg of their trip to the host's laboratories and areas of sightseeing. I and other foreign visitors find that the warm hospitality of the Japanese leads to close friendships which are so beneficial to both parties for professional progress. With the combination of such close friends and the natural beauty of the country, it is no wonder that it is so easy to fall in love with Japan.

NATIONAL RESEARCH INSTITUTE FOR METALS

Earl F. Skelton

While on assignment at ONR-Tokyo to exchange information with Japanese scientists in the general area of high pressure science and technology, I had the good fortune to spend more than one week working in the laboratory of Professor Shigeru Minomura at the Institute for Solid State Physics of The University of Tokyo. One of the experiments in which we have had a mutual interest is the high pressure synthesis of Nb_3Si into a cubic crystallographic form, the so-called A15-structure, in which it is expected to exhibit highly favorable superconducting properties. It was in this context that we spent one afternoon visiting the laboratories of Dr. Kyoji Tachikawa at the National Research Institute for Metals.

Dr. Kyoji Tachikawa's group is generally concerned with the fabrication and evaluation of new and improved superconductors; in particular, attention is directed to materials with improved superconducting critical temperatures (T_c), critical fields (H_c), and critical currents (J_c). Synthesis techniques developed at the National Research Institute for Metals are usually patented, if appropriate, and subsequently reported to the scientific community through both technical meetings and the open literature. It is the intent of the Institute that ultimately these new procedures would find their way into commercial production applications.

At present, their efforts may be divided into four general areas: (1) Studies of texture in V_3Ga and Nb_3Sn amorphous superconductors; (2) Development of improved C15-crystals, i.e., the so-called Laves phases of V_2Hf, V_2Zr, and Nb_2Hf. Interest in these Laves phases is due to their superior mechanical properties as compared to the more popular A15-compounds. Dr. Tachikawa reports that at liquid He temperatures the Laves phases exhibit high critical fields, e.g., 200 to 260 kOe, and that they are also significantly more ductile than the A15-materials. For example, the hardness of these C15-compounds is about 60% lower than that of the more brittle A15-materials. Thus they are expected to have more favorable performance characteristics. Moreover, it is noted that these Laves phases exhibit a high resistivity to deterioration from neutron irradiation; this of course would have important consequences for neutron fusion applications.

(3) A third area of interest is the development of V_3Ga multifilamentary (MF) wires and tapes for ultimate application in high field superconducting magnets. In this program there is also some testing and evaluation of commercially produced materials underway. For example, recent efforts to measure values of J_c under pulsed current excitations of MF-V_3Ga wire produced by the Furukawa Electric Company have indicated that this wire is quite stable and consequently useful for windings in high field magnets with large exciting speeds.

(4) The fourth and perhaps most active area of research concerns the fabrication of Nb_3Ge and other high temperature superconducting materials. Dr. Tachikawa and his associate, Dr. Haruki Kawamura, have reported successfully synthesizing both Nb_3Ge and Nb_3Si in the A15-structure through utilization of chemical vapor deposition (CVD) techniques. In the case of the Nb_3Ge compounds, appropriate chlorides ($NbCl_5$ and $GeCl_4$) were heated in the presence of a hydrogen gas atmosphere to temperatures ranging from 800 to 900 C. The substrate consists of a this strip of Nb which was held at a temperature about 50 C above that of the hydrogen atmosphere.

Successful formation of Nb_3Ge in the A15-structure was realized with substrate temperatures in the 850 to 950 C range. At 900 C, Dr. Tachikawa reports that a 10 micron layer of Nb_3Ge can be deposited in about 3

minutes. Values of T_c (measured at onset by a four-lead resistive method) vary from about 18 to 21.5 K for samples prepared under slightly different reaction temperatures and with small compositional variations. The measured lattice parameter of 5.15 A and T_c of 21.55 K for the best sample are a little larger and smaller, respectively, than the best Nb_3Ge material produced. (The current maximum value of T_c is reported for sputtered films of Nb_3Ge: 23.2 K (Ref. 1 and 2)). Moreover, electron microprobe microanalyses performed at the Institute reveal a Ge concentration of 21 to 22 atomic % (at. %). This departure from a stoichiometric composition is consistent with the slightly low value of T_c and may, in part, be due to small amounts of dissolved hydrogen impurities.

Most recently the group at the National Research Institute for Metals has greatly increased the yield of its CVD production capabilities by replacing the Nb substrate plate with a continuous belt of Hastelloy tape. The tape is about 3 mm wide and 0.1 mm thick and consists of the following compositional weight percentages: Ni = 52; Cr = 21; Fe = 18; Mo = 9. Basically the CVD techniques are similar to those employed for the stationary substrate, however, in this process a thickness of 5 microm. of Nb_3Ge can be deposited continuously at a substrate speed of 8 mm/sec. It was found that both the lattice parameter and T_c values indicated a further departure from the ideal stoichiometric composition, viz., a minimum lattice parameter of 5.16 A and a maximum T_c (onset) of 20.5 K. However subsequent chemical analyses again revealed the Ge concentrations to be similar to those found with the static substrate, viz., 21 to 22 at. % Ge. Although the cause of this small compositional difference is not completely understood, a possible explanation may lie in small compositional variances or impurities in the reaction chamber. Work on this problem continues with a major emphasis directed toward gaining better control of the Nb:Ge concentrations in hopes of driving the deposited film to the desired 3:1 stoichiometric composition.

Similar CVD efforts have also led to successful synthesis of Nb_3Si in the A15-structure. As noted above, based on empirical arguments, this compound is expected to exhibit extremely favorable superconducting properties. Unfortunately the compound formed at the Institute, although having the desired A15-structure, has a maximum T_c (onset) of 8.05 K, far below the expected extremum. Basically the procedure used for forming Nb_3Si is similar to that employed for Nb_3Ge, with the obvious substitution of $SiCl_4$ for the Ge chloride.

Under increasing reaction temperatures, from 800 to 900 C, the lattice parameter of the Nb_3Si compound was observed to continuously decrease from 5.23 to 5.16 A with a corresponding increase in the Si concentration from 8.6 to 22.5 at. %. Surprisingly, however, the maximum value of T_c (8.05 K0 was obtained for an intermediate sample with a lattice parameter of 5.23 A and Si concentration of 10.9 at. %. No explanation of this extremum in T_c so far from the stoichiometric composition is offered. Moreover, work on this material appears to have been discontinued at the Institute, at least, for the present, a major reason being the relatively low values of T_c found.

In another effort to produce Nb_3Si in the A15-structure, this team had succeeded in splat cooling samples with 22 at. % Si concentration. Regrettably the measurable parameters were not encouraging: lattice parameter = 5.155 A and T_c (onset) = 5.4 K. However, it is to be noted that there was no evidence of the presence of any second phase in the x-ray data. This work too appears to have been discontinued.

On the whole, the group in this section of the National Research Institute for Metals appears to have a very positive and excited attitude toward its research. Much of the equipment I saw in the laboratories is of a very modern design and indications are that the group is reasonably well funded for the continuance of its research program.

REFERENCES

(1) J. R. Gavaler. Appl. Phys. Lett. *23*, 480 (1973).

(2) L. R. Testardi, J. H. Wernick, and W. A. Royer. Solid State Comm. *15*, 1 (1974).

JAMSAT AND OSCAR-8

Earl F. Skelton

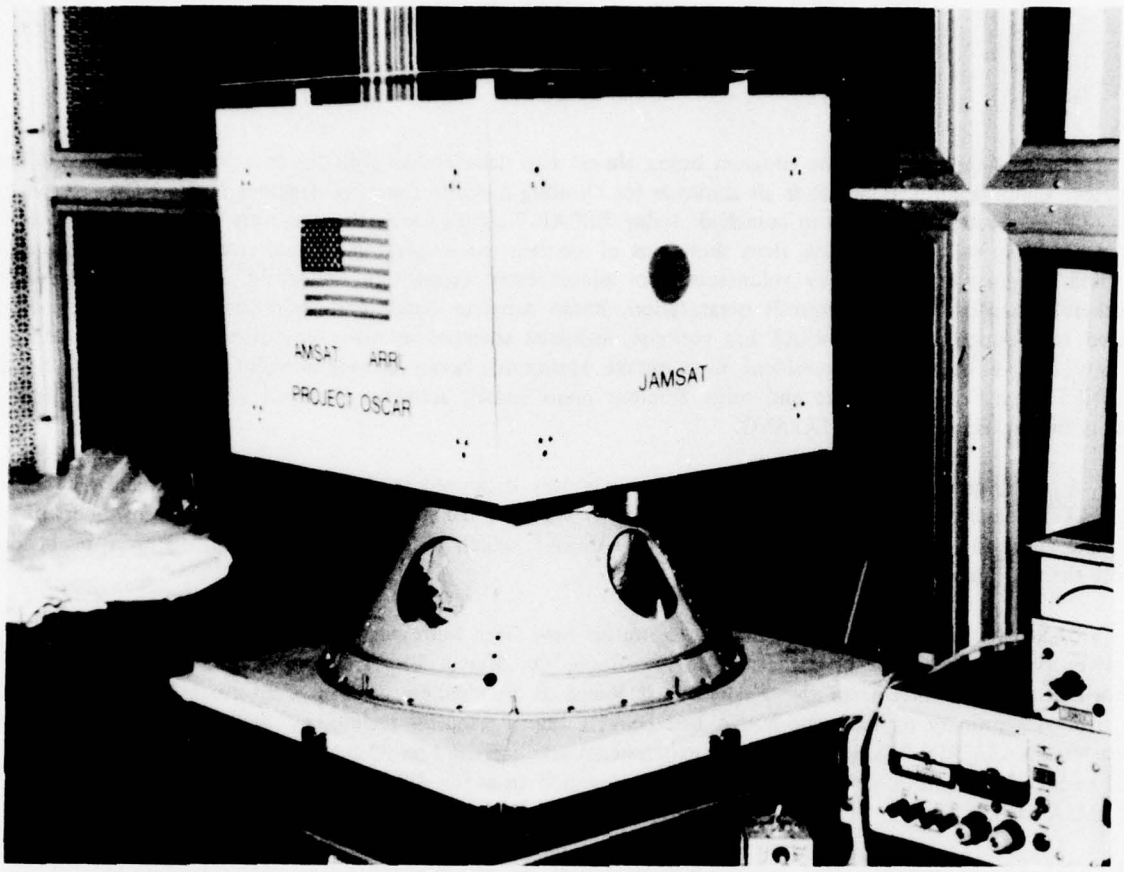
The amateur radio satellite program began almost two decades ago with the launch of OSCAR-1, the first amateur radio satellite. (OSCAR is an acronym for *O*rbiting *S*atellite *C*arrying *A*mateur *R*adio.) Over the years, six additional satellites have been launched: today OSCAR-7 circles the earth once every 115 minutes, providing an active relay station for signals from thousands of amateur radio operators located around the world. Support for this program is provided by volunteers from almost every country in the world. This team of dedicated workers is headed by the nonprofit organization, Radio Amateur Satellite Corporation, or AMSAT for short. Based in Washington, DC, AMSAT has national, affiliated societies in many countries; the Japanese affiliate society is JAMSAT and its president is Shigetake Morimoto, better known in radio circles by his call-sign, JA1NET. Many of the satellite and other amateur radio related activities in Japan are directed by JAMSAT vice-president, Haruo Yoneda, JA1ANG.

A small group of amateur satellite enthusiasts was organized in Tokyo in early 1972 and The Japan AMSAT Association, JAMSAT, was founded in 1974. Many of the more active and progressive members of the original group are currently serving as officers of JAMSAT, which today boasts of a membership roster bearing more than 200 names.

Recently many amateur radio satellite operators have been more active than usual and much of this extra activity is a direct result of earlier JAMSAT efforts. On March 5th, 1978, NASA successfully launched a Thor-Delta 2910 rocket from the Western Test Range at Vandenberg AFB in California. The launch vehicle carried, as a primary payload, the NASA LANDSAT-C (earth resources technology satellite); secondary payloads were two NASA PIX (plasma interchange experiment) satellites, and an AMSAT OSCAR-D spacecraft. One hour and twenty-five minutes after lift-off, OSCAR-D separated from the Thor-Delta and, in so doing, became known as AMSAT OSCAR 8.

This newest amateur radio satellite was built over the last two years by amateur satellite enthusiasts in Japan, the United States, Canada, and West Germany. It is in a sun-synchronous, polar orbit and, based on preliminary flight information, orbital parameters are very close to design values, i.e., period = 103.232 minutes; increment = 25.804 degrees/orbit; mean altitude = 914 km. Designed for a lifetime of three years, OSCAR-8, with its two communications transponders (active radio relays) plus command and telemetry systems, can be operated in any of several modes. Batteries recharged from solar cells provide power for all the electronics carried onboard the 60 pound, 15x15x13 inch space craft. (See photograph)

One communication mode (Mode A) is very similar to that used on both OSCAR-6 and -7, viz., signals are received in a portion of the amateur 2-meter band (uplink: 145.85 - 145.95 MHz) and retransmitted in the amateur 10-meter band (downlink: 29.40 - 29.50 MHz). In addition to this however, OSCAR-8 can also be operated in Mode-J ("J" for JAMSAT). This involves a new transponder built entirely by JAMSAT; the project manager for the Mode-J hardware was Haruo Kanawa, JA1JHF. The individuals most actively involved in the construction of this transponder include Haruo Yoneda, JA1ANG; Yasuhiro Yokota, JA1CBL; Koichi Kurachi, JG1CDM; Akira Munezuka, JA1VDV; and Mikiyasu Nakayama, JR1SWB. In addition, JAMSAT assistance was also provided for the fabrication of the power system through the efforts of Osamu Yamamoto, JA1TUR, and Hideho Yamamura, JF1DMQ.



When operated in Mode-J, OSCAR-8 will be accessed in the uplink frequency range 145.90 - 146.00 MHz and the relayed signal will be in the amateur VHF 70-cm band (downlink: 435.10 - 435.20 MHz). The peak-envelope-power of the relayed signal is about 1 to 2 watts. The uplink sensitivity is typically about -105 dbm and consequently relatively little transmitter power is needed from most ground stations, generally less than 10 watts eirp. In addition, when operated in Mode-J, a 100 mw beacon at 435.095 MHz provides telemetry information concerning the temperature, charging and total current, battery voltages, and rf power output of the satellite. Although OSCAR can relay FM, AM, and other types of rf signals, for purposes of minimizing the energy drain on OSCAR's batteries and accommodating the largest number of users within the passbands, the more efficient CW, RTTY, SSB, or SSTV communication modes are recommended.

Like its predecessors, OSCAR-8 will be used internationally by thousands of amateur radio operators for both satellite communication and experimentation, but more importantly, OSCAR-8 will also serve as an educational tool. Countless demonstrations and lectures on the science and technology of satellite operations have been, and will continue to be, given at educational institutions spanning the entire academic spectrum from elementary schools to universities. In most cases, these involve active usage of the OSCAR satellites themselves. Moreover, the orbital radius of OSCAR-8 is only slightly more than half that of OSCAR-7 (560 versus 910 statute miles). This unique combination of active amateur radio satellites provides interesting possibilities for inter-satellite relays, e.g., the downlink for OSCAR-7 operated in its Mode B is in the 2-meter band, consequently input signals for OSCAR-8 could be relayed via OSCAR-7. The propagation and Doppler effects resulting from this situation are very unique and interesting.

Another vital role played by JAMSAT vice-president Haruo Yoneda, JA1ANG, is that of a communication link between the West and the greater Asian and southern Pacific areas. JA1ANG maintains a weekly schedule with Jack Colson, W3TMZ, in the Washington, DC, area whereby pertinent satellite, UHF, and VHF communication data are exchanged between Washington and Tokyo. The other half of this communication link is maintained through a weekly 20-meter Asia-Pacific AMSAT net involving stations in Australia, India, Indonesia, Malaysia, New Zealand, the Philippines, Singapore, South Korea, Thailand, and countless islands in the Pacific (held every Sunday at 11:00 UTC at 14.28 MHz). Thus information regarding the latest developments in the amateur space program and updates of vital satellite data are exchanged regularly between operators in this part of the world and their counterparts in Africa, Europe, North America and elsewhere.

Additional information concerning this exciting space-age hobby, the upcoming AMSAT Phase-III space program and the Russian planned radio-amateur Sputnik may be obtained directly from JAMSAT, P.O. Box 117, Tokyo Central Post Office, 100-91, Japan, or from AMSAT, P.O. Box 27, Washington, DC 20044.

THE ANOMALOUS WINTER THUNDERSTORMS OF THE HOKURIKU COAST: PRELIMINARY REPORT ON SECOND YEAR'S RESEARCH

Marx Brook

Last winter (1976-1977) we verified that the storms of the Hokuriku area do indeed produce anomalous lightning. That season, in eight of nine lightning flashes to ground, the charge lowered to earth was positive instead of the usual negative observed in summer storms. A network of four stations was used, with electric field and field-change instruments to measure the qualitative electric properties of the clouds and discharges. The data were meagre, however, justifying a second try with improved instruments and an expanded network of stations.

In the winter of 1977-1978 the network was enlarged to seven stations and additional equipment was installed which provided a continuous and absolute calibration of the measuring instruments. In this way it was possible to obtain quantitative data on the sign and magnitude of the lightning charges brought to earth and on their location in the cloud. Preliminary data analyses were obtained for two lightning strokes: 1) natural lightning which originated about 6.5 km above the surface and which brought 12 coulombs of positive charge to earth; and 2) triggered lightning which was initiated by a small rocket fired vertically, raising a 0.2 mm diameter grounded wire. The charge was 17 coulombs, negative, located about 4 km above ground.

The triggered lightning is of special interest because it is probable that aircraft which fly through these clouds often initiate lightning in the same manner. Three tragic aircraft accidents of recent years in the Hokuriku area are believed to have happened as a result of triggered lightning initiated by the penetrating aircraft.

The complete analysis of the 1977-1978 data will take some months. The results of the two preliminary analyses are encouraging and help to elucidate the electrical structure of these small but vigorous storms. There are presently no plans for continued United States involvement in this program. However, the author hopes that his Japanese colleagues will continue to probe this fascinating anamoly.

Scientists involved in this research in addition to the author were Dr. T. Takeuchi, Mr. M. Nakano and Dr. K. Horii of the University of Nagoya, Dr. S. Aiba from the Kanazawa Institute of Technology and Dr. C. Magono and Dr. T. Endoh from the University of Hokkaido. United States-Japan cooperation was evidenced not only in the joint participation of scientists from both countries but also in the joint funding of this research. Japanese funds came from the Ministry of Education and the Japan Society for the Promotion of Science. United States funds came from the Office of International Programs and the Atmospheric Research Section of the National Science Foundation and from the Atmospheric Sciences Program of the Office of Naval Research. Acknowledgement is made to all of these agencies for their generous and considerable help in this effort.

RHEOLOGY IN AUSTRALIA

Elliot A. Kearsley

Several times during my visits to Australia it was pointed out to me that as late as 1948 the first Ph.D. was awarded in Australia. Indeed, up to the post-war era Australia pretty much looked to Great Britain for leadership in culture and science. To this day there seems to be a local air of pragmatism (a sort of frontier pride in the practical) which colors the Australian outlook. Yet academic science seems strong there, and even a specialized field such as rheology is represented by a good fundamental program. Rheology is principally done at two centers, the University of Sydney and Monash University, but beyond these relatively large groups, smaller one- and two-man efforts on particular problems can be found at scientific research establishments throughout Australia. There is an Australian branch of the British Society of Rheology, and an irregular newsletter on rheology is published (see CSIRO below). Australian scientists often travel to the United States and Europe and many Australian academics come from overseas. There is generally good knowledge of the latest developments around the world, at least at the major centers. This is certainly true of rheology.

UNIVERSITY OF SYDNEY

The University of Sydney is the oldest of the Australian universities and the original Engineering Department dates from 1882, which is ancient indeed in Australian terms. In the Mechanical Engineering Department I found Professor Roger Tanner well settled and surrounded by an active group of colleagues and graduate students. A few years ago Roger returned to the University of Sydney from a professorship at Brown University, Providence, Rhode Island. There he had developed a wide reputation for the originality and incisiveness of his contributions to rheology. This reputation is being maintained in Australia where he directs (among other things) a program on constitutive equations for describing polymer melts and solutions. He is fortunate in a particularly promising and productive student, Mr. Nhan Phan-Thien, who has developed and is exploiting a constitutive equation for rubbery fluids derived from a model of the creation and destruction of the rubbery network junctions. The rates of changes of junctions are supposed to depend on the instantaneous elastic energy of the network. This sort of thing has been done before, but the novelty in this case is that the network junctions are assumed to move non-affinely with respect to the macroscopic deformation of the fluid; that is, "slippage" of the junctions is assumed. (Mathematical rheologists will be enlightened on hearing that the result is a particular anisotropic fluid of the Ericksen type.) The model has two parameters (functions of shear rate) and satisfies the proper time-temperature superposition principle. A preliminary application to the analysis of shear data and extension data of polyethylene (found in the literature) seems encouraging.

Phan-Thien has also been active in kinetic calculations of suspensions of dumbells as models of dilute solutions. Unlike Bird and his colleagues at Wisconsin who work on these problems with a phase-space formulation, Phan-Thien's approach is from the Langevin equation. He claims that this approach allows him to introduce internal frictions and a varying friction factor between the beads of the model without logical inconsistencies. Calculations with the model show two particularly interesting features. The dumbells can maintain an extended configuration at only moderate rates of elongation of the fluid field. In a varying flow field the model exhibits a hysteresis loop. The thought is, as you may suspect, that this model may serve to throw some light on the well-known but still unexplained drag reducing effects of extremely dilute polymer solutions in turbulent flows. Phan-Thien has also looked at the much simpler problem of pulsitile flow of a generalized Maxwell model of a fluid. Since the viscosity of such a material ordinarily decreases at high shear rates, one would expect fluctuations of the mean pressure gradient to stimulate the flow on the average. The

details of the dependencies of the various parameters are quite interesting. Much of Phan-Thien's work is about to be published (or is just published) in the *Journal of Non-Newtonian Fluid Mechanics*, the *Transactions of the Society of Rheology* or *Physics of Fluids*.

Roger Tanner has been a proponent of finite-element methods of calculating "rheological" fluid mechanics problems. He has honed his finite-element tools on some simpler problems in the past. Using Newtonian fluids he has calculated the drag of an infinite cylinder in flows of varying Reynolds number. Some of his rough calculations of the shear-stress on the walls of a model of branched blood-vessels have been used in a physiological study of induced blood clotting. But one of the most annoying unsolved problems of polymer rheology is the calculation of die-swell, the increase in diameter of a cylinder of polymer as it is extruded from a die. The problem is technologically important and scientifically interesting. It is easy to formulate, but because it is a free-surface problem (the boundary of the material must be calculated) and for more subtle reasons it is extremely difficult from a mathematical point of view. Now, Tanner and K. R. Reddy, a colleague, are about to launch an assault on the problem. At a recent fluid mechanics meeting in Adelaide, they gave a paper on the two dimensional analogue to the problem – the extrusion of a sheet. While it is true that a very simple rheological model was used (second-order fluid) and the calculation was confined to low Reynolds numbers, the success of the program serves to demonstrate the suitability of a Galerkin method at a crucial step in the calculation. Of course there remains the problem of generalizing the scheme to accommodate axisymmetric geometry and more complex constitutive equations. Roger tells me that he is not yet prepared to attempt finite-element calculations with hereditary constitutive equations (for which stress depends on the past history of strain), but, in my opinion, that will ultimately have to be achieved.

Another project at this laboratory is investigating the flow of viscoelastic fluids through porous media. This is a subject of importance in the melt-spinning of fibers, but also in the so-called "tertiary" methods of improving the recovery of oil from wells. There is therefore much interest in the problem now, around the world. Tanner tells me that he finds the published data generally incomplete or sometimes inconsistent and he feels that the phenomenology needs clarification. He and M. V. Keento are presently generating a set of data using water solutions of high molecular weight polymers (separan and polyox). The porous media they use are beds of packed glass beads of various sizes. The rheology of this flow situation should be quite interesting since one would expect the mechanical properties in extensional flow to play a leading role. Ultimately they plan to look at polyacrylic materials for which the chain configurations in dilute solutions can be altered through control of the pH of the solution.

When one shears a fluid of any significant complexity, an anisotropic stress is set up in addition to the obvious shear stress. The practical measurement of the components of this stress tensor (called the measurement of normal stresses) is perhaps the most central of rheological experimental problems. In the recent past Professor Tanner has contributed much ingenuity to his problem and he continues to be involved. He is equipped with an Instron rotational rheometer (which he helped to design) for ordinary measurement of normal stress (usually using shearing between a cone and a plate). A more novel apparatus which is just being constructed will shear a fluid between two non-parallel plates. The analysis of the resulting flow has been beautifully worked out by Alan Pipkin, the well-known applied mathematician and Tanner's former colleague at Brown University. Tanner will measure the stress distribution against one of the plates by means of flush-mounted solid-state devices. The experiment should give reliable measurements of the second normal stress difference, a particularly difficult quantity to measure. Another technique for measuring this quantity (useful in the range of low shear rates and small stresses) requires measuring the surface configuration of fluid flowing under gravity down a tilted open channel of semi-circular cross-section. This method was worked out by Tanner and Pipkin just before Tanner's return to Australia but the experimental program had not been completed then. Tanner tells me he intends to complete the experiments using a photographic record of the reflection of a straight-edge on the fluid surface to measure the configuration. He tells me that the idea was suggested to him by a trivial remark in a recent paper of mine. I am very pleased. Other projects in the offing with this group include the development of a rotational viscometer to use in blood rheology studies (only beginning) and various engineering studies aimed at solar-energy development (which is a very active field in Australia).

In the Chemical Engineering Department of the University of Sydney I found other work going on with at least overtones of rheology. Associate Professor John R. Glastonbury has a continuing interest in particle-liquid hydrodynamics and mass transfer in stirred vessels. Naturally, his work has a strong chemical engineering flavor and is of great interest to the mining and ore treatment industries which are so important to the Australian economy. He has been instrumental in pointing out the dangers of scaling up engineering results simply on the basis of power input per unit mass. (This sort of scaling is a result of reasoning from the assumption of Kolmogoroff isotropic turbulence to explain particle-liquid mass transfer.) His work is usually published in *Chemical Engineering Science*. It has important implications in the design of fluidized combustion and the gassification of coal. In the same department, Drs. R. J. Hunter and T. Vande Ven are studying the flocking of colloids and the effects of shearing on these flocks. From stress-strain curves of shearing these materials, they obtain parameters which they relate to the micromechanics of the system. They have designed a special rotational rheometer to make the necessary measurements of these complex materials.

MONASH UNIVERSITY

In contrast with the ancient origins of the University of Sydney, Monash University was founded as late as 1961 to help accommodate the postwar boom in tertiary education. ("Tertiary education" is the accepted term for education beyond high school in Australia.) Looking today on the bustling campus (250 acres in Clayton, urban suburb of Melbourne) it is hard to credit the recent origins. The University is named for Sir John Monash, Commander of the Australian Army Corps in the First World War and an engineer who subsequently directed the development of coal production and electrical power generation for the state of Victoria. Appropriately, the engineering departments at Monash seem to be particularly well nurtured.

In the Chemical Engineering Department, there is a considerable activity in rheology. The department has an academic staff of 12, chaired by Professor O. E. Potter whose specialty is chemical reaction engineering. He is currently active in research on fluidized bed studies, in particular gas-liquid reactions, moving-bed studies and some associated heat and mass transfer problems. Three senior lecturers, D. V. Boger, C. Tiu and P. H. T. Uhlherr, are principally interested in rheological chemical engineering. These three researchers with their graduate students staff one of the principal centers for rheological research in Australia.

The linchpin of the rheological activities at Monash is undoubtedly David Boger. I have always enjoyed his Australian twang on the several occasions at international meetings when I heard him. Imagine my surprise then, to discover that he was born and raised in Pennsylvania, that his doctorate is from the University of Illinois and, to top it all off, that he is known around the university for his "Yank accent." He maintains a close connection with Professors Mort Denn and Art Metzner of the University of Delaware and has done considerable collaborative work with them.

The rheological program of this group at the Monash University Department of Chemical of Engineering is particularly active in five projects.

1. Their work on flow of viscoelastic fluids into the entry or exit of a pipe is perhaps the most complete study of this important problem of any rheology laboratory. This geometry is that of a polymer melt flowing into a spinneret in commercial fiber production or of flow into the die of extrusion molding or flow of material from a reservoir into a capillary rheometer. It is known that these flows are stable at low flow rates but that for viscoelastic materials large vortices develop in the reservoir at the entry of the pipe. Perhaps related to this is the fact that at Reynolds' numbers well below that for classical turbulence, instabilities occur in the flow, sometimes as periodic disturbances superposed on otherwise stable flow, sometimes as a spiralling disturbance at the entrance or exit of the pipe. This sort of instability is often referred to as "melt-fracture," (a term coined by Tobolsky I believe) but that name may be quite misleading. The Monash group has some striking motion pictures of these effects (which I understand they can be persuaded to lend out).

The aim of this project is to relate the kinematics of these exit and entry flows to material properties. Although substantial progress has already been made, the problem is still far from solved. It is known for instance that the circulations at the entry region can be eliminated by fitting the pipe with a gentle conical entry, but that this does not necessarily eliminate the instabilities. It is known that elastic effects, inertial effects and viscous shear thinning can each contribute to the kinematics, perhaps by interaction. At Monash the inertial effects have been elucidated to a great extent by experiments with water solutions of polyacrylamide (Separan), which is highly elastic with a relatively low viscosity. Polymer melts, on the other hand, have a relatively high viscosity and should exhibit kinematics in processing flows more nearly independent of inertia. Boger's latest game is to look at these flows with a material having high, constant viscosity and high elasticity. "Where does he get such a material?" you ask. The secret is to use a dilute solution of a very high polymer in a very viscous solvent. In Boger's case the material is polyacrylamide in maltose syrup. For this material, with shear rates of about 10 $sec.^{-1}$ he finds normal stresses of almost 10^3 $newtons/meter^2$ (an indication of strong elastic effects) and an apparently Newtonian viscosity of about 10 poise. His expectation is that this material will single out the purely elastic effects in the kinematics of the flow.

2. Recently Boger published a short note [*Nature 265* pp. 126-128 (1977)] in which he displays the measured viscosity of a polyacrylamide solution over six decades of shear rate. The curve was a typical one illustrating "pseudoplastic" behavior. There was a low shear-rate region in which the fluid looked Newtonian and a high shear-rate region in which it again looked Newtonian (but with different viscosity). Boger found that he could fit this data with an empirical model (Meter model) using four parameters. It is extremely unusual to see data on a single sample over such a large range of shear-rate. (To obtain this data Boger had to use three different instruments.) But the real point of the note was to underline the fact that each of the four parameters had to be determined by the characteristics of a different part of the curve. In other words, it is not possible to predict one end of the curve from the data of the other end and such extrapolations (although not uncommon in industrial laboratories) are unjustified. As a consequence of these ideas, there is a project at Monash for the development of and verification of techniques of measuring important thermoplastics under the conditions they undergo during processing. The first fruits of this program will soon appear in a review paper done jointly with Denn and Metzner of the University of Delaware. It will review the use of capillary exit flows to measure the elastic properties of materials (a common way of dealing with polymer melts at high shear rates). The paper will correct some common misconceptions about the method and will outline recommended conditions for use of the well-known Han method of exit pressure measurement.

3. Australian honey and commercial molasses usually contain dextran. (I have no idea if the same is true for products of other countries.) This dextran affects rheological properties of the substances and presents difficulties in the commercial processing. The details of the effects of dextran on the flow properties of such materials is now being elucidated.

4. Red mud is a waste product accumulated in alarming quantities in the course of producing aluminum from bauxite. Any method of improving the handling of this material would be of great value. Studies of the flocculation and flow of red mud are an important program at this department. General methods for measuring the flow properties of settling slurries are being developed and the slurry transport of coal is being considered.

5. A project (somewhat related to the last mentioned) is concerned with the motion of falling particles in non-Newtonian fluids. The detailed flow patterns and the wall-effects are being studied.

If you are a collector of rheological curios (and what rheologist is not), a recent note by Boger and P. J. Cable (Rheol. Acta *16* pp. 322-323 (1977)) is worth a look. In that note they report a jump in the curves of normal stress of polyacrylamide solutions versus shear-rate measured with a Weissenberg Rheogoniometer. (The shear-stress showed no such anamoly.) My discussions with Boger and the details in the note reveal no obvious explanation. Since the discontinuity occurs at different shear rates and different values of normal stress for different solutions (but only for polyacrylamide solutions), it is hard to think of a reasonable instrumental cause.

Could it be some sort of unknown instability in the flow? Boger thinks it indicates a property of the material, but if it is a property which jumps according to shear-rate, that is indeed a curio!

Other rehology related projects at least in the planning stage at this department include: the rheology of synovial fluid and the lubrication of human joints, flow through porous media of rheologically complex materials, hydrodynamic drag reduction by dilute solutions of polymers, heat transfer in flowing viscoelastic fluids and the effects of drag-reducers in turbulent flows on heat transfer.

There is also rheology related research in other engineering department of Monash University. Drs. Brian Cherry and Kevin Thomson, for instance, are in the Department of Mechanical Engineering and are looking at crack propagation with epoxy specimens. They use double cantilever beam samples (DCB samples) in Mode I, that is, they induce cracking by pulling apart the two beams formed by partially sawing a plate of cast polymer. The sample plate is 10 mm thick, but a grooved track of 3 mm thickness guides the crack. It is well known that in such a configuration if the cantilevers are pulled apart at a slow but constant speed, at some instant an unstable crack will suddenly extend along the groove and then arrest until sufficient stresses again build up at the crack tip to cause another unstable jump. Even at higher speeds of separating the cantilevers when the crack propagation appears to be steady, it is thought that this is only because the short crack-jumps occur so rapidly that they appear steady. Cherry and Thomson found that, in studying crack initiation, in order to get consistent results it was necessary to start from a natural crack. That is, they first produce a crack by initiation from the original sawn crack, by using a fixed crosshead speed (0.05 cm/min or 0.2 cm/min gave mutually consistent results). Upon arrest of this crack the loading is changed to a new crosshead speed and the time to fracture initiation from the "natural" precrack is measured. In their experiments these times varied from 20 seconds to 22 minutes at crosshead speeds from 0.2 cm/min to 0.005 cm/min, respectively. The quantity called G_c, the critical strain energy release rate for unstable crack initiation, can then be calculated from the applied load and the precrack length. (A calibration of the compliance of the cantilever system must also be done separately.)

Roughly, the results of this work can be summarized in two important points:

1. In this work with plastics, artificial cracks do not give data characteristic of the material properties.

2. The value of G_c determined from a precrack seems to relate to crosshead speed in a way that suggests that material relaxations cause a "blunting" of the crack tip. Hence the apparent initiation fracture toughness can vary by as much as an order of magnitude depending on the crosshead speed of the test and the relaxation time of the material.

CSIRO DIVISION OF CHEMICAL ENGINEERING

The Commonwealth Scientific and Industrial Research Organization (CSIRO) is a federal agency which conducts a large fraction of the total Australian effort in scientific research. A more complete description of CSIRO will be left for a later report, but at least a brief mention should be made here of the rheological activities of the Division of Engineering, which is located on the campus of Monash University. Dr. A.V. Rama Murthy has set up there a laser doppler anemometer with which he maps out the kinematics of extrusion through a die. The apparatus is tied into a computer and the operation is really quite convenient. Rama Murthy uses polyacrylamide solutions as samples (and paraffin as a Newtonian "control"). He finds that the spiralling instabilities (mentioned above) at the die entry lead to travelling transverse waves in the fluid flowing through the die and ultimately cause distortions of the extrudate. On the other hand, high frequency fluctuations which produce a matte or sharkskin surface in the extrudate do not seem to relate to die entry conditions.

Kevin Hall, a principal research scientist at this laboratory, has been active in rheology in Australia for many years. He serves as an unofficial expert on rheological questions for other CSIRO groups and has been active on the CSIRO Steering Committee on Rheology which organizes symposia and makes recommendations to

speed the solution of rheological problems throughout CSIRO. His personal researches started with studies of combustion which led to fluidized beds and to problems of mixing and thence to rheology. Currently he is considering the problems of long distance transport of minerals by piping of slurries. He continues to be interested in problems of scale-up of mixing processes. The Division of Chemical Engineering was included in the group of Minerals Research Laboratories of CSIRO some time in the recent past. Consequently the interest of this group is turning toward the handling of mining materials.

Bits of rheological research occur in other of the many CSIRO laboratories scattered throughout Australia. Dr. P. U. A. Grossman in the Division of Building Research, for instance, is actively interested in the rheology of wood. The textile research groups are very important to CSIRO because of the Australian wool industry and there are several activities in fiber rheology. The Rheology Steering Committee publishes (irregularly) a small newsletter, *CSIRO Rheology*, with news and brief accounts of CSIRO activities. Unfortunately the regular distribution is limited to CSIRO scientists.

THE FLINDERS UNIVERSITY OF SOUTH AUSTRALIA

Adelaide is a charming little city at the far western end of the heavily populated southeastern corner of Australia. There are two universities there. The University of Adelaide is the old traditional (by Australian standards) university in the center of the city. Flinders University is a new shiny university perched on a hillside in a southern suburb with a magnificent view out to the bay. Here in the Department of Mathematical Science you can find Dr. Raja R. Huilgol, recently of Illinois Institute of Technology in Chicago. Huilgol was once a student of Tanner at Sydney University but subsequently spent some years in the United States. He is the author of *Continuum Mechanics of Viscoelastic* which recently received some very favorable reviews. The flavor of this book, mathematically elegant but encompassing significant experimental results from the literature, is typical of Huilgol's research style. More currently, he has been active in characterizing flows of constant stretch history (an important kinematic concept). This concept was introduced by B. Coleman some 15 years ago and elaborated on by W. Noll, C. C. Wang and others. The importance of the concept is that it spans a class of flows broad enough to include many frequently encountered situations such as viscometer flows and extensional flows, yet for flows within this class only a few parameters need be measured to characterize a fluid. Huilgol has developed a practical algorithm to determine whether a given flow is within this class (a surprisingly subtle question) and hence, whether a large body of mathematical results can be applied to the analysis of the flow. In a somewhat different vein, Huilgol has been working with a priori bounds. He has calculated bounds for the swell-ratio in the ubiquitous die-swell problem and some bounds (improved over the recent ones of Truesdell and of Fosdick and Serrin) for the work done by an irreversible heat engine. Further on the die-swell problem, he works with Dr. B. Omodei of Flinders on finite-element methods of calculating the flow. (This particular problem must have been a major topic at a recent fluid mechanics meeting in Adelaide since Huilgol of Adelaide, Tanner of Sydney and Boger of Melbourne were each planning to attend). More recently, Huilgol has become interested in bifurcation theory. He is applying it to a problem of the "hunting" of a railroad train axle, i.e., the periodic motions superposed on the steady velocity. While this problem is in no sense rheological (after all, Huilgol is a mathematician, not a rheologist) the mathematical techniques of bifurcation theory are particularly applicable to questions of mechanical stability in general. Rheology is just getting to the point where the subtle questions of stability are emerging as the important questions (with some hope of solution). I will be very much surprised if Huilgol, given his past experience, does not soon find himself applying these ideas to rheological problems.

THE AUSTRALIAN NATIONAL UNIVERSITY

The Australian National University (ANU) is unique in a number of ways. It is located in Canberra A.C.T. (Australian Capital Territory is the Australian analogue of the District of Columbia), it is not associated with a state of the Commonwealth, and, most significantly, it is funded by direct federal appropriations. The University was set up in 1946 when the federal government of Australia first began to take on the responsibility of supporting higher education. ANU is really two distinct institutions, the School for General Studies (which is in

fact a complete university with undergraduate and graduate students) and the Institute for Advanced Studies (IAS) which is Australia's most prestigious research institution. The IAS is a most desirable location for a scientist because the financing is aimed at long-term projects rather than the short-term "one-shot" grants offered by other government agencies. IAS itself is composed of several schools.

At the John Curtin School of Medical Research (JCSMR) of IAS is Professor L. W. Nichols of the Department of Physical Biochemistry. His work cannot really be called rheology since it is best described as the study of biomaterials by physical-chemical methods, but a good bit of polymer solution work is done. All the latest equipment of a first-rate polymer physics laboratory is there: ultra-centrifuge, light-scattering apparatus, dichroism and GPC equipment for instance. As is typical throughout IAS, this department has a small permanent staff (about 5) and a larger number (a dozen or so) of bright young post-doctoral scientists who come for three to five years' tours. (Nichols tells me that it is also sometimes possible to help American scientists who wish to come for short projects of a few months' duration.) Some Ph.D. students are also accepted. This system of staffing was praised for the continuous infusion of new ideas and enthusiasm that it engenders, but Professor Nichols remarked to me on the resulting continual loss of good tried associates. There is no utopia! But the scientific atmosphere at JCSMR comes through as superb. There is a much encouraged teatime arrangement (often encountered at Australian institutions) for which a special lounge was fitted out with comfortable seats and a good supply of paper and pencils. Talk is encouraged between personnel of the different departments. Nichols tells me that it is here that the communications barrier between the laboratory and clinical personnel is broken down and that good cooperation has been traced directly to this tea lounge. (Some of his own research has found clinical application by this route.) The secret, he says, is that formal talks are not encouraged at tea, but informal exchanges are.

As an example of the sort of work done in the Department of Physical Biochemistry, I was told of the work on hemocyanin, the chemical which acts as the oxygen carrier in the blood of crustaceans. The oxygen-carrying ability of this material shows a typical sigmoidal curve against concentration, a fact which is important to the physiology of the crustaceans. The hemocyamin is very large molecule which can combine to form oligimers. Nichols suspects that the source of the sigmoidal curve is in the geometry of the molecules, that is, concentrated solutions of hemocyamin form more dimers or other oligimers in such a way as to hide the active sites on which the oxygen attaches. This mechanism causes the "saturation knee" of the curve. Although the details of the process are not completely understood yet, the evidence, so far, is favorable. This principle is presumably active in many other biochemical processes. The slight rheological aspects of the problem are to be found in the solution-property studies which are used to give information on the degree of oligimerization of the molecules.

Subsequent to my trip to Canberra, I discovered that a small project is supported at ANU by the Australian Research Grants Committee on the measurement of normal-stress coefficients by holographic interferometry (L. O. Brown and H. G. Hornung). That would have been worth investigating and I am sorry to have missed the chance.

THE UNIVERSITY OF NEW SOUTH WALES

The University of New South Wales is a post-war university in Sydney. Not long ago it was known as the University of Technology and there remains a distinct technological flavor. It is a university widely reputed for its engineering departments. In rheology, the best known work done here was that of Professor F. W. Ayscough who established some structure/property relationships of vinyl polymers. Very recently Professor Ayscough left Australia to accept an appointment as director of a technological institution in Hong Kong. Presently there is very little strictly rheological research going on at the University of New South Wales, although the university offers the only formal program in Australia leading to a degree of Master in Polymer Science. There is some rheology related work worth a mention. Professor Haken is a widely known expert on coatings and uses gel permeation chromatography (GPC) as a technique for materials control. Dr. T. S. Hickie, a lecturer in textile

testing, has designed new and novel equipment for testing wear and flammability. He also works on the problem of designing acrylamide cloth filters for particle collection in industrial stacks as a cheap substitute for expensive electrical precipitators. He tells me that with careful design the filters are often a more economic solution to the problem of controlling air pollution. Professor C. H. Nicholls is active in research on flash photolysis and has some interesting results with films dyed with photoconducting material. Dr. R. P. Chaplin, a lecturer (recently from the National Research Council, Ottawa) does polymer synthesis and GPC studies.

There is a close connection maintained with industry at this university. I was interested to hear that a non-profit company, Unisearch Limited, undertakes contract research on a commercial basis using the facilities and staff of the University. The company's income is then donated to the University. The operation provides an invaluable service to companies too small to maintain their own research laboratories.

THE BREAD RESEARCH INSTITUTE OF AUSTRALIA

In North Ryde, outside of Sydney, is the Bread Research Institute of Australia (BRIA). Although it is a private organization supported principally by subscriptions from the baking industry, it is located on a complex with the CSIRO food research laboratories with which there are frequent collaborations. A program of study of the rheology of bread dough which continues there, originated some years ago when Nick Tschoegl (currently professor of chemical engineering at Cal Tech) began his rheological career at BRIA. At one time this program was partially supported by the United States Department of Agriculture. Bread dough is such a variable material, depending on the materials and handling, that customarily some rather pragmatic tests are used to grade quality or suitability of wheat flours. The aim of this program in rheology of bread dough is to find more fundamental relationships between material properties and quality of dough so as to allow a more exact and quantitative evaluation. Dr. G. E. Hibberd of BRIA and Dr. N. S. Parker of CSIRO have developed a special instrument to measure viscoelastic properties of bread dough. The device shears the dough between parallel flat plates one of which slides on an air lubricated linear bearing. Shear stress can be applied by a pulley and weight mechanism and displacement is measured with an electromechanical transducer. The device has been used over two orders of magnitude of shear stress and the very simple geometry is most appealing. Although only shear stress has been looked at so far, the addition of slotted plates and solid-state pressure transducers would allow normal stress to be measured also. It is a particularly useful device for very soft materials.

AWA RESEARCH LABORATORY

Elliot A. Kearsley

Amalgamated Wireless (Australasia) Limited (more widely known by its initials AWA) is Australia's largest communications company and almost certainly the only one which undertakes state-of-the-art research in electronics as a private venture. By Bell Labs standards it is a small operation indeed since there are only about 150 scientists and engineers among its 4500 employees. The size of the company reflects the fact that the Australian market is small and demands particular commercial strategies. First, for the short term the company develops highly specialized high-priced equipment for narrow markets (usually government contracts). Second, for the long term they try to parlay this through further development for commercial applications with relatively large markets by Australian standards. The well-known Australian partiality to horse-races notwithstanding, it is not true that the AWA race-track totalizator systems are the principal product of this company. Rather, this is an example of their third strategy: to seek selected special commercial equipment development problems where their small size is not a disadvantage.

The AWA Research Laboratory at North Ryde, a suburb of Sydney, has a staff of only about 15. Nevertheless it is remarkable what it has been able to achieve. Currently the development of fiber optics is underway in a project involving about six professionals. Of course, there is now world-wide interest in fiber optics which give promise of supplanting (some time in the future) most electrical communication wiring and even, to some extent, microwaves. It is a very competitive field. To a degree, the success of fiber optics systems depends on keeping down the transmission losses. This is achieved by, among other things, using low loss quartz fibers in which the index of refraction varies in the cross-section so as to enhance the critical-angle/total-reflection effect at the surface. About six years ago the AWA Research Laboratory picked up an idea from CSIRO, the government research organization, and developed methods of manufacturing fibers with a liquid core. The advantage to this scheme is that the liquid used is easy to purify chemically and transmission losses can be kept extremely low. But ultimately, it was decided that the thermal expansion difference between quartz and liquid is too troublesome and a new approach was sought. They then developed a technique of vapor-depositing borosilicate material inside a quartz tube which is then pulled out into an optical fiber. These fibers are now being made commercially by AWA. On the drum they have a transmission loss of only 3db/kilometer and when made up into a cable the losses typically are still only 6 or 7 db/kilometer. (The difference is attributed to scattering caused by local stresses.) Currently continuous fibers can be supplied in lengths of two kilometers. The index of refraction change is in one step with a phosphosilicate core and borosilicate cladding. AWA quotes a numerical aperture of 0.22 and a band width of 20 to 50 MHz at one kilometer (depending on details of the construction). These fibers are good enough to enjoy international sales, to France for instance, but the principal users are as yet mostly military. With strategy two in mind, AWA notes that Australian telephone exchanges in the highly populated southeast corner of the country are spaced particularly well for the use of fiber optics. They are currently proposing to the telephone company a fiber optics system of linkages which will eliminate the need for intermediate amplifiers. Meanwhile, the Research Laboratory is developing practical methods of manufacturing better fibers with an optimum radial variation of index of refraction. This is to be achieved during deposition of the core by computer control of the changing chemical composition of the vapor. Other work is underway related to the splicing of cables, coupling to LED's and other problems of the auxiliary hardware.

Optical fiber transmission systems can take advantage of the non-linearity of laser sources to work particularly well in pulse transmission. However, in contrast to conventional microwave methods, only positive pulses can be sent. The optimum coding of information for transmission by fiber optics is thus somewhat

different from conventional codes. To take full advantage of the channel capacity it is desirable to have groups of even numbers of pulses and no big gaps between pulses of a group. Thus turning on and turning off can each contribute a bit of information without excess power requirements. Work on such optimum codes for fiber optics is underway at AWA.

AWA Research Laboratory has been responsible for the production of a number of digital and analogue optical fiber communication systems. For a government contract, they conducted a field trial of a system with underground and overhead installations of 2 kilometers of optical fiber cables. There was two-way transmission of multichannel data and also delta-modulated voice transmission. The optical fiber line-rate was said to reach 6 Mbits/second.

Radio was AWA's original business and research continues on the estimation and measurement of the propagation of radiowaves in the frequncy range from broadcast bands up to UHF. Studies are going on of coding for error control and modulation on digital transmissions over stable and unstable radio paths.

Rayleigh waves, which occur at the surface (within a wave length) of elastic media, are a part of classical physics which, until recently, was mostly of interest to seismologists. But in 1965 in *Applied Physics Letters*, White and Voltmer reported on an electrical method of exciting and detecting these surface waves on a piezo-electric substrate. Because of the slow speed of acoustic waves, this technique is very convenient for making devices such as delay-lines. The equivalent devices based on electromagnetic waves can be inordinately big and are usually much lossier. But the most important advantage of the surface acoustic wave (SAW) device is that the wave is accessible throughout its path, to modify or to interact with. These advantages were already apparent in 1965 and researchers have been quick to use them. The AWA Research Laboratory began research on surface acoustic waves in 1969 with a study of the basic physics. Subsequently they have produced various devices: filters, oscillators, delay lines, digital signal encoders, phase shifters and resonators. These devices have generally been based on quartz as a piezoelectric substrate and have been in the frequency range of 10 to 650 MHz. The major work has been on oscillators and a complete SAW oscillator-modulator system was developed. A computer program for simulating SAW oscillator behaviour has been very useful in optimizing designs.

Other activities of this organization include instrument calibration, environmental testing and reliability testing. There is a Standards Laboratory within the research laboratory with equipment to make all the usual electrical calibrations to good accuracy and a Climatic and Durability Testing Laboratory which can generate a good range of temperatures, humidities, pressures and vibration and shock for tests of lifetime in adverse environments.

Electret is a term originally proposed as an analogue to the term *magnet*, that is, it refers to materials with a bulk distribution of permanent electric dipoles. Actually, the term as now used has been generalized to include any dielectric material for which either polarization or charge distribution persists for times long enough to be considered permanent. AWA Laboratories is currently active in electret research. The reasons for their interest has to do with the development of cheap reliable telephone microphones. I was surprised to hear that Western Electric Company in the United States is virtually the sole source of good carbon for microphones and that the supply is limited. (What is Western Electric's source was not explained.) Anyway, it looked promising to AWA to examine some alternative possibilities for cheap, reliable telephone microphones. Electrets can be used to supply the polarizing fields in electrostatic microphones, playing a role analogous to the field magnet of a magnetic device. Alternatively, they can be used as pressure (or temperature) transducers since the distribution of charges or dipoles is affected by a change in volume. The program on electrets was begun at AWA in 1968. The initial efforts resulted in enough understanding of the physics to allow development of practical commercial manufacture of electrets. The first electrets had been made by cooling Carnauba wax while it was in a polarizing electric field. The solidified wax then carries a "permanent" polarization. However the electrical properties of such electrets change over a long time, (often resulting in a reversal of the field) so that they are not really satisfactory for commercial designs. The whole explanation of these changes is quite complicated and has to do with the

interactions between the polarization and surface charges (induced during poling) and the subsequent drift of the charges and decay of the polarizations. (The principal work on these questions was done over 30 years ago by Bernard Gross, the Brazilian physicist also known for his rheological research.) The key to making good electrets is to use better materials and better polarizing/charging methods. Drs. R. E. Collins and P. W. Chudleigh at AWA Research Laboratory looked at the physics of many methods of polarizing and charging electrets. They ended up with a method of charging FEP Teflon (a Dupont copolymer) through contact with conducting liquid. The resulting electret foils are sufficiently stable for charge decay to be unimportant in most applications and the method is very convenient from a manufacturing point of view. This has led to the construction of an advanced prototype electret telephone handset utilizing an electret microphone with a single-chip integrated circuit. It is being evaluated by Telcom Australia as a replacement for the present carbon microphone sets. The next developmental work will be aimed at electret hydrophones which seem particularly promising for high-sensitivity, low-frequency applications.

An invaluable tool in this study of electrets has been a really clever apparatus for measuring the distribution of charge and polarization through the thickness of a dielectric film. In its simplest form, the device consists of a sample film mounted under a slight tension with a thin metal electrode deposited on one side and a spaced electrode on the other. A short pulse of light is directed at the deposited electrode where it is absorbed, causing a wave of thermal expansion to travel through the sample. The effect of the expansion on the polarization and charge density is seen in a time-trace of the voltage between the electrodes. Collins has been using an ordinary cheap electronic photo-flash for the light pulse (- 80 μ seconds). But, there is some delicate technique necessary in evaporating on the metal electrode (400 A° of aluminum is recommended) and in mounting the film under a slight stabilizing tension. Also, the electronics called for are quite modern (MOSFET amplifier for instance) as befits research at an electronics company. The analysis of the data requires the inversion of an integral equation. As you might expect at this electronics laboratory, this mathematics was accomplished by constructing an analogue electrical circuit and matching the recorded data by adjusting the analogue output. The appropriate charge distribution is then read off from the analogue "charge" adjustments.

While this technique of data analysis is undoubtedly convenient, it leaves me with an uneasy feeling. I always like to see a careful mathematical study of such inversion problems, if only so that I understand the ultimate limitations. In fact, even without mathematics, it's clear in this case that the technique is going to work more accurately for the hot side of the film, because that is where the highest gradients of density will occur. (This effect is remarked on by Collins.) But that is a fine point. The results Collins displays are impressive. His calculated charge distributions for aged electrets charged by liquid contact clearly show the charges diffusing from the charged surface into the bulk material with increased aging. Electrets charged by energetic electron beams give quite different traces showing that the electrons lodge closely spaced within the dielectric at a depth depending on the energy of the beam.

Consider that, until now, the only way to get such data has been to section the electret physically and then measure the total charge per section (not even possible with thin films). The Australian Research Grants Committee was also impressed since they supported the work with the only grant this year to a private commercial laboratory.

Some time ago, Collins visited my home laboratory, the Polymers Division of the National Bureau of Standards (NBS), and set up a copy of his apparatus there. I understand that it is being used there to study poled films of polyvinylidene flouride (PVF_2), which is a piezoelectric material in the form of a flexible film. (The PVF_2 study at NBS is partly supported by ONR.) I met Dick Collins during his visit to NBS, and we have been good friends since. Recently I heard that he is about to accept an appointment at the New South Wales Institute of Technology. Surely he will continue this interesting work.

AWA maintains a technical journal, the *AWA Technical Review* which publishes readable reports of researches at a good scientific level and occasional general articles on technological trends.

NATIONAL INSTITUTE OF RADIOLOGICAL SCIENCES

Francis A. Richards

The principal facilities of the National Institute of Radiological Sciences (NIRS) are at Inage, Chiba Prefecture, around 30 kilometers southeast of Tokyo. The Institute was formed in 1957 and is under the Science and Technology Agency (Minister of State for Science and Technology). The Director, Dr. Keisuke Misono, is also a member of the Japan Atomic Energy Commission, which reports directly to the Prime Minister's Office.

The NIRS mission is to contribute to basic and applied research in all aspects of the peaceful uses of radioactivity and atomic energy. Much of the research is in the field of biomedicine, and among their facilities is a medical cyclotron. The hospital is for research on the treatment of cancer patients. To study the effects of chronic exposure to low-level radioactivity a facility for the rearing of pathogen free experimental animals has been completed recently. The facilities also include a Van de Graaf Accelerator Laboratory.

The Inage facilities house three project research divisions and 12 basic research divisions. They also include the research hospital, a training school, and other facilities. Two additional research divisions, The Division of Radioecology and the Division of Marine Ecology, are at the Nakaminato Laboratory in Ibaraki Prefecture, near the Tokai nuclear establishments (The Japan Atomic Energy Research Institute, a power reactor, the Nuclear Fuel Reprocessing Plant, and the Uranium Enrichment Plant).

The Nakaminato divisions and the Division of Environmental Health are all concerned with problems associated with radioactive materials in the environment. The chief of the latter is D. R. Ichikawa. These divisions were the principal interest of the writer.

Much of the work I saw was concerned with the effects of various dosages of radiation on differing cancerous cells being grown in tissue culture. Impressive, controlled environments were being used but my ignorance of both cellular biology and of Japanese language prevented anything but a very superficial understanding of what was going on in this area.

Dr. Ichikawa's own research is with ^{60}Co in the food chain, particularly the uptake of the radionuclide in cyanocobalamine, vitamin B_{12}. ^{60}Co is produced by nuclear power plants, where the radioactivity is induced by neutrons impinging on metal piping. In culture experiments, ^{60}Co has been shown to be taken up by unicellular algae of the genus *Chlorella* and by green algae of the species *enteromorpha.* The plants presumably convert inorganic forms of ^{60}Co to organic ones, especially vitamin B_{12}, which is then preferentially absorbed by rats fed on the algae. Compounded in the vitamin, ^{60}Co is taken up preferentially over inorganic forms by the placenta and embryos of experimental animals.

Another section of the Environmental Health Division is concerned with a continuing survey of natural radiation, from cosmic rays and from the earth, in the environment. Areas high in granite, such as Kyoto, have high background radioactivity whereas Tokyo is low in natural radioactivity. Much of India is high because of the presence of monazite sands. In Colorado, tailings from uranium mines are used for paving, piping, etc., giving a high radiation background.

The Environmental Health Division also collects and disseminates radioactivity survey data, publishing it under the title Radioactivity Surveys Data in Japan. Number 42 was issued in April, 1977, and reported on the

effects of the 18th, 19th, and 20th nuclear explosion tests in the Peoples' Republic of China. The monitoring includes 1) gross beta radioactivity in the upper air, 2) gross beta radioactivity in rain and dry fallout, 3) gross beta radioactivity in airborne dust, 4) iodine-131 concentrations in fresh milk, 5) hot particles, 6) strontium-90 and cesium-137 in soil, 7) ^{90}Sr and ^{137}Cs in source waters, and 8) dietary samples, including fresh and powdered milk and tea. The monitoring and analyses are carried out by various agencies including the Japan Meteorological Agency, the Research and Development Headquarters, Japan Defence Agency, The Japan Chemical Analysis Center, NIRS, and various prefectural institutes and laboratories.

NIRS also publishes a journal *Radiological Sciences* in Japanese.

I later visited the branches of NIRS at the Nakaminato laboratories in Ibaraki Prefecture, the Division of Radioecology and the Division of Marine Radioecology. These divisions are housed in good quarters near the seashore and are supplied with running seawater, important to many of the studies of the Division of Marine Radioecology.

The Division of Radioecology is concerned with the passage of natural and artificial radioactive materials from their sources through the environment and especially from the environment through the food chain to man. The division has excellent laboratories for beta and gamma spectrometric analyses of radionuclides and conventional chemical analyses.

Studies are continuing on the movement of strontium-90 and cesium-137, both produced during nuclear test explosions, in the soil, rivers and ground water and the contributions these nuclides make to internal exposures. Other studies are concerned with human intake of radionuclides through agricultural and dairy products. These involve investigating the chemical behavior of radionuclides in soil and transfer rates from soils to plants (including pasture lands). Iodine-131 is a radionuclide of special interest. It is produced and introduced into the atmosphere by nuclear facilities and represents gaseous radioactive elements. Its rates of deposition on plant leaves are being followed.

A major concern of the Division of Radioecology is the establishment of baseline values of radioactivity in the environment, in crops, and in man. These are the "Reference Man" studies and involve the elemental composition and physical dimensions of organs and tissues of the human body and the metabolic involvement of such radionuclides as ^{137}Cs, ^{90}Sr, and ^{131}I. To be able to evaluate the effects of possible changes in radioactive exposures, the Division conducts surveys on food consumption in Ibaraki Prefecture, where there are major nuclear facilities (power, fuel reprocessing, uranium enrichment plants).

In summary, the Radioecology Division is concerned with all aspects (except marine) of the pathways of natural and man-made radionuclides from their point of origin through the environment and ecosystem to man and their lodging sites in humans.

The Division of Marine Radioecology has much the same mission as the Radioecology Division except it is concerned with the marine environment and marine ecosystem. In both divisions the emphasis is on the consequences of radioactive contamination to the environment, the biota, and humans.

The marine ecology studies include both field programs and laboratory experiments. The field programs are designed to predict the transport and accumulation of radionuclides in the ocean. This requires investigations of the present distributions of both radioactive and stable trace elements; physical oceanography (currents, circulation, mixing, transport, etc.); biological uptake and concentration of trace elements; and geochemical cycles of trace elements through the water column, suspended and living particles, and sediments. In some instances tracer experiments with a dye (rhodamine B) are carried out, the spread of the dye simulating the spread of radioactive materials. Japan plans to release low level radioactive materials directly into the ocean from some of the nuclear facilities at Tokai; this operation will provide the opportunity to observe the oceanographic

and geochemical fate of such substances. The dumping will be in shallow, coastal zone waters (1.8 km offshore in water 20 m deep). However, transport and distribution of radionuclides in the deep ocean are also studied.

A major effort in marine ecology is devoted to the study of the uptake and accumulation of radionuclides by marine organisms. It has been known for years that many elements are concentrated by marine organisms by large concentration factors (concentration factor = concentration in organism ÷ concentration in seawater). The factor may be in the thousands or hundreds of thousands. There are many processes by which the accumulation takes place: adsorption and absorption, assimilation in body tissues, and incorporation into shells and skeletal materials; different elements are concentrated differently by different organisms. It is thus important to understand as thoroughly as possible which elements are concentrated by what organisms and the subsequent fate of the organisms in the food chain. So, much effort is being devoted to laboratory studies in which marine organisms are exposed to known concentrations of both radioactive and stable elements and to following the accumulation in the organism. The laboratory studies are complemented by field studies in which natural concentration factors are determined by analyzing both seawater and marine organisms for both radioactive and stable organisms. The laboratory is well equipped for neutron activation analyses (the samples are radiated at Tokai) and atomic absorption spectrometry.

The distinctive facilities of the division are aquaria of many sizes used for the nuclide uptake experiments and the good supply of seawater to the laboratories.

JAPAN METEOROLOGICAL AGENCY

Francis A. Richards

Japan Meteorological Agency (JMA) deals with both the atmosphere and the ocean, is thus akin to National Oceanic and Atmospheric Administration (NOAA), and renders many of the same services. The agency is concerned with both research and applications; forecasting weather and oceanographic conditions are important functions. Other parts of the agency are the Meteorological College; the meteorological, seismological, and magnetic observatories; the Meteorological Consultative Committee; and the Meteorological Research Institute, all under the Ministry of Transport. The activities in oceanography and maritime meteorology are carried out by the Marine Department. Dr. Jotaro Masuzawa is head of the department, which has oceanographic, meteorological, and general affairs sections. My interest was primarily in the Oceanographic Section, which is headed by Dr. Masao Hanzawa, who spent several years at the headquarters of the World Meteorological Organization in Geneva. Drs. Masuzawa and Hanzawa gave me a general rundown of the oceanographic activities and then turned me over to my fellow chemist, Dr. Tetsuro Suzuoki, who is head of the section for chemical analysis for pollutants. Dr. Suzuoki is a graduate of the Department of Earth Sciences of Nagoya University, where he worked closely with Professor Ken Sugawara, whom I consider to be the dean of Japanese Water Chemists.

Before turning to the chemical work of the oceanographic section it will be useful to discuss briefly the oceanographic services of the Marine Department. The basic data gathering is carried out at five Marine Observatories (at Hakodate, Maizuru, Kobe, and Nagasaki, with the central agency in Tokyo functioning as the fifth). In addition to the landbased work each observatory operates an oceanographic survey ship. Tokyo also operates the ocean weather ship *Keifu Maru* (1796 tons) for maritime meteorological observations. In addition, one of two patrol ships, the *Ojika* (861 tons) and the *Nojima* (869 tons) occupies ocean weather station TANGO (29°N, 135°E) from late May until early November, the typhoon season, each year.

The oceanographic survey ships are:

Ryofu Maru (Tokyo)	1599 tons
Seifu Maru (Maizuru	355 tons
Kofu Maru (Hakodate)	346 tons
Chofu Maru (Nagasaki)	266 tons
Shumpu Maru (Kobe)	373 tons

These ships occupy a network of stations surrounding Japan four times each year. Their observations routinely include physical, chemical, and planktonic variables, and special observational and sampling programs are also carried out. The latter programs have included sediment sampling, heat flow and magnetic observations, and the measurement of micro-seismicity using ocean bottom seismographs. In addition, *Ryofu Maru* occupies two long sections, one south from Japan along 137°E to New Guinea, the other along 155°E from about 10°S to 30°N. The section along 137°E was first occupied in 1967 as part of the International Cooperative Studies of the Kuroshio (CSK) program. It is occupied twice each year, in winter and in summer. The 155°E section has been occupied each summer since 1972 when it was established as part of the Japanese National program for pollution monitoring. The winter cruise is completed by occupying stations from the New Guinea end of the 137°E section to the Bashi Channel, between Luzon and Taiwan, and then on to Tokyo.

The ocean data from the marine observatories and the ships are supplemented by data from ocean data buoys. These are 10m in diameter and weigh 43 tons. Each samples 16 variables eight times a day; the data are

telemetered in real time via an HF radio link to the agency's Weather Communication Station, where the data are processed and disseminated to various users. Modification of the buoys for data transmission via satellite is in the trial stages and should be completed in 1978. Even after modification, transmission by the HF radio link will continue. Both oceanographic and meteorological variables are sampled: wind speed and direction, air and dew point temperatures, atmospheric pressure, water temperatures at depths of 3, 20, and 50m, significant wave height and frequency, global radiation, current speed and direction, salinity, and orientation and inclination of the buoy. By 1975 two of these buoys were in operation and three have now been launched. The operating buoys are in the East China Sea (28°20'N, 126°05'E in 115m of water), the Japan Sea (37°45'N, 134°23'E in 2590m of water) and the Pacific south of Japan (25°40'N, 135°55'E, 3470m of water). A fourth is to be moored in 1978 in the Pacific east of Japan (39°30'N, 145°30'E, 5555m of water).

The main mission of the Marine Department is the forecasting of oceanographic conditions for the use of ships at sea. However, the data are widely disseminated to and used by the scientific community. Special observations and the collection of special samples for the scientific community are not uncommon; acknowledgements of these efforts are frequent in Japanese scientific papers.

The data from the oceanographic observations are processed at JMA headquarters and published twice a year in the *Results of Marine Meteorological and Oceanographical Observations.*

The chemical activities of the Marine Department consist of standard oceanographic observations of chemical and biological variables (chlorophyll and phaeophytin) and the activities of the Chemical Analysis Center for Pollutants headed by Dr. Suzuoki. This program includes two projects under the general auspices of the Intergovernmental Oceanographic Commission (IOC): MAPPMOPP [Marine Pollution (Petroleum) Monitoring Pilot Project] within the framework of the Integrated Global Ocean Station System (IGOSS) and GIPME - Global Investigation of Pollution in the Marine Environment.

MAPPMOPP, as the name implies, is a pilot project that was initiated in 1975 and is scheduled to terminate in 1978. There are three main objectives to this project: 1) the visual observation of floating pollutants (mostly plastics and oil slicks), 2) the sampling of floating tar balls, and 3) the determination of dissolved or dispersed petroleum hydrocarbons in surface water. These observations are made at specified stations of the routine network occupied by the survey ships of the marine observatories. There are 15 of these stations around Japan. In addition, the *Ryofu Maru* occupies eight stations on the 137°E section between Japan and New Guinea twice a year, winter and summer, and nine stations along 155°E in the summer. The 137°E section is now augmented by 12 stations on the homeward track via the Bashi Channel.

An attempt is made to quantify the visual observations of floating pollutants by following standard observation and reporting procedures specified in the MAPPMOPP observation manual. The tar ball collection is more quantitative; they are collected during a standard tow at four knots for one mile with a JMA Standard Neuston net. This skims a swath 750mm wide so that one tow represents 1400 square meters of surface. The tar balls are then hand separated, weighed, and reported in terms of milligrams per square meter of sea surface. Collecting nets are washed with carbon tetrachloride between uses. Up to 10mg/m^2 of tar balls were observed in the Kuroshio off Japan in the summer of 1977, and in the winter of 1978 one sample from east of the Bashi Strait contained 24.2mg/m^2. The material from the northern part of the area was very pitchy, sticky, and fresh; it probably arises from tanker flushings after offloading oil in Japan.

Dissolved or dispersed hydrocarbons are determined by a spectrofluorometric method, so only aromatic hydrocarbons are detected. This method was selected by the IOC because of its relative ease and the comparability of results. However, this is still a pilot program, and the methodology will be discussed at a workshop to be held sometime toward the end of 1978. The Meteorological Agency is planning to use gas chromatography coupled with mass spectrometry to characterize and quantify hydrocarbons; the gas chromatograph is already on hand.

JAPAN METEOROLOGICAL AGENCY – FRANCIS A. RICHARDS

The GIPME program, also a project of the IOC, was started in 1972 and is directly coordinated with oceanographic activities required by Japanese laws for environmental protection. The program is concerned with cadmium and mercury distributions, and the observations are made at the same stations as the MAPPMOPP observations. Samples are collected from the surface and from 1000 meters.

Cadmium is determined using a dithizone extraction followed by atomic absorption. The routine method for mercury is not too sensitive; it involves direct reduction of the mercury with stannous chloride followed by flameless atomic absorption. To increase the sensitivity, the metallic mercury is concentrated by amalgamation on gold and then measured by flameless atomic absorption.

The Chemical Analysis Center for Pollutants participates in the World Meteorological Organization (WMO) Network for Background Air Pollution Monitoring. This program, which is in the framework of GEMS (Global Environmental Monitoring System) was started in 1972 to monitor atmospheric pollution, including precipitation, dry fallout, meteorological data, etc. The samples are from a land station at 39°2′N, 141°50′E. They are analyzed for such constituents as sulphide, chloride, nitrate, nitrite, ammonia, sodium, potassium, calcium, magnesium, carbon dioxide, pH, conductivity, etc. To improve the coverage of the air pollution monitoring, a regional station in Nagasaki Prefecture to represent western Japan and a baseline station on Chichijima Island are planned.

Results of the chemical analyses are reported "promptly" by the Marine Department in a publication called *"Prompt Report of Observations for Monitoring Background Marine Pollution."* An appendix includes the atmospheric background pollution observations. Most of the data are displayed as oceanographic sections and include the routine observations made by the ships of the marine observatories as well as the GIPME and MAPPMOPP marine data. The seven routine sections include water temperature, salinity, dynamic depth anomaly, current speed and direction, dissolved oxygen, reactive and total phosphorus, nitrate-, nitrite- and ammonia-nitrogen, chemical oxygen demand, hydrogen ion concentration *in situ*, total datoms in the surface water, *chaetognatha and net weight of plankton* in the 0 to 150-m water column, chlorophyll *a* and phaeophytin. A map of the geostrophic flux in the upper 1,000-m layer is included. The GIPME data are displayed as horizontal distributions of cadmium and mercury at the surface and at the 100-m level.

To be able to evaluate the effects of the activities of man on his environment baseline studies and continuous monitoring are essential. The GIPME project is a scientific approach to the problem of environmental pollution in which JMA is an active participant.

On touring the laboratories of the Chemical Analysis Section I was shown an impressive array of analytical instruments - mostly of Japanese origin, some based on foreign instruments (e.g., a Hitachi-Perkin Elmer 139 UV-VIS spectrophotometer), some imported, such as a Technicon AutoAnalyzer. Like most well-behaved chemical oceanography laboratories, few people and few instruments were about – most were at sea on *Ryofu Maru* making oceanographic observations. Good atomic absorption equipment was on hand as was their Oceanographic Instruments Total Carbon System, although the ampoule sealer was at sea, being used for collecting samples for later analysis.

The chemical laboratories are equipped for salinity determinations. For more routine work an Australian-made inductive salinometer is used. More precise determinations are made by potentiometric titration. There is an elegant Swiss made instrument for this work. One responsibility of the laboratory is to determine the salinity of Japanese Standard Seawater. (See article on this subject in this issue.)

The equipment and methods for biological observations were rather standard. "Chlorophyll" at the surface is measured continuously with a Turner fluorometer, which is also used for continuous profiling of chlorophyll in the upper layer using a pumping system. As indicated above, the biological observations include chlorophyll and phaeophytin, numbers of diatoms in the surface water (cells/liter), total number of individual chaetograths per

m^3, and net weight of plankton in the upper 150m of the water column as collected with a NORPAC net. The biology section of the Marine Department is small – only three members – and their main work is that of classifying phytoplankton. No other biochemical variables are included in the program.

The Marine Department produces a large number of products and publications. These include:

1) Results of Marine Meteorological and Oceanographical Observations (twice a year)
2) Prompt Report of Observations for Monitoring Background Marine Pollution (every six months)
3) Manual for Oceanographic Observation
4) The Ten-day Marine Report, charts of 10-day mean sea surface temperatures covering the area 10-35°N, 110-180°E
5) The Oceanographic Atlas of the Northwestern Pacific, Vol. 1 shows the 15 years (1956-1970) normal monthly sea surface temperatures in the Northwestern Pacific (10-50°N, 110-180°E)
6) The Oceanographical Magazine is published semi-annually and contains research results in oceanography, marine geophysics, maritime meteorology, etc.
7) Guides and manuals for maritime meteorological observing and reporting
8) Report on the Severe Rainstorms in Japan
9) The Marine Climatological Tables of the North Pacific Ocean (annual)
10) Tide Tables, the monthly Tidal Report, and the annual Tidal Observations.

The Marine Department of JMA appears to be an efficient, professional organization carrying out its basic mission, which could be defined as the business of making regular and reliable oceanographic observations for the purpose of constructing predictive models and making predictions of oceanographic conditions for the use of the seagoing public - the merchant marine, fishermen, the defense forces, pleasure boaters. It enjoys a good international reputation and has been involved in a number of international organizations and programs. Included are:

IOC	Intergovernmental Oceanographic Commission
CSK	Cooperative Studies of the Kuroshio
IGOSS	Integrated Global Ocean Station System
WMO	World Meteorological Organization
WWW	World Weather Watch
GARP	Global Atmospheric Research Project
ICG	Inter-Union Commission on Geodynamics
IPOD	International Programme of Ocean Drilling

JAPANESE STANDARD SEAWATER

Francis A. Richards

Standard Seawater ("Normal Water," *Eau de mer normale*) is used in oceanography for the determination of *Chlorinity* and *Salinity*. For the benefit of non-oceanographers, these are fundamental variable properties of seawater; they are measures of the salt content, and the two are related by a constant factor. The chlorinity classically has been determined by a highly standardized analytical procedure, the Knudsen titration. More recently the salinity, which is also related to the electrical conductivity, is more often determined electrically in a salinometer. The salinity, temperature, and pressure determine the density of seawater, a critical variable in physical oceanography.

To make salinity and chlorinity determinations universally comparable, analyses have been referred to international Normal Water, which since the turn of the century and until recently, was prepared in the Laboratoire Hydrographique in Copenhagen, Denmark ("Copenhagen Water"). More recently it has been prepared by the Standard Seawater Service at the Institute of Oceanographic Sciences in England. The original standard was prepared by Professor Martin Knudsen in 1902, and until 1937 all batches of Normal Water were compared, directly or indirectly, with the 1902 standard. The earlier series was carefully compared with a new batch prepared in 1937 (Urnormal - 1937).

Availability of Normal Water to the oceanographic community has been interrupted by two world wars. As a consequence, various national measures have been taken to assure continuous supplies, if not of the international standard itself, then of acceptable derivative standards for oceanographic use. The first such Japanese derivative or secondary standard was prepared in 1941, and the practice has continued ever since. New batches are prepared only every other year, so I considered it a fortunate chance to be able to visit Rigosha & Co., Ltd., at a time when the standard water was being prepared.

Seawater for the Japanese standards is collected near the Ogasawara Shoto (Bonin Islands), because the salinity in this area is close to the desired value of 35‰. Various ships, primarily the *Yofu Maru* and *Takuyo Maru* of the Hydrographic Division Maritime Safety Agency, or the *Umitaka Maru* of the Tokyo University of Fisheries, collect the samples. Seventy or eighty 20-liter polyethylene bottles of water are collected at a time; these are set aside for five or six years to allow remineralization of their organic content. After this time the water is filtered through a fine pored sintered glass filter and transferred to either 100-liter enameled steel or 300-liter polyethylene containers and mixed. The salinity of the water is then checked by a standard Knudsen titration in the analytical chemistry laboratory of the Japan Meteorological Agency and determined approximately by hydrometer at the company.

So that it will compare with the international standards, the final chlorinity of the secondary standards should be between 19.35 and 19.40‰, a good "average" value for the Atlantic Ocean. As the collected water is less saline than this, the chlorinity is increased by removing 10 liters from every 100 liters and evaporating the 10 liters to a calculated volume. The concentrated water is then mixed back with the remaining 90 liters. At this point the water is bottled in 20-liter glass-stoppered glass containers to prevent further evaporation and poisoned with mercuric chloride (1 ml of a saturated solution for each 100 liters of seawater. Of course, this causes a very small chlorinity change).

Things are then ready for introducing the water into ampoules. The contents of 2½ of the 20-liter bottles are mixed to make a lot. While the lot is constantly stirred, the water is forced by air pressure into the open

ampoules (either 100 or 200 ml; when I visited, 200-ml ampoules were being filled) through a thin glass tube connected to the reservoir by a rubber tube. This is when the inspections begin.

The preparation of Japanese standard seawater is directed by a committee appointed by the Japan Science Council. It consists of some 10 members representing the Council, the Japan Meteorological Agency, the Meteorological Research Institute, the Hydrographic Division of the Maritime Safety Agency, the Ocean Research Institute of Tokyo University, and the Tokai Fisheries Research Institute, with a representative of the Rigosha Company attending meetings as an observer. Dr. Yasuo Miyake, former director of the Meteorological Research Institute and of its Geochemical Laboratory and until the end of 1977 a member of the Japan Science Council, has been Chairman of the Committee since its first formation in 1941.

All the procedures that the company follow have been approved by the supervisory committee. Cleansing the ampoules is very important. The adopted process is simple and appears to be effective. Ampoules are filled ½ to ¾ full of distilled water and shaken on a mechanical shaker for 20 to 30 minutes. After draining, the insides are steamed on a manifold for another 30 minutes in a covered container kept a little above room temperature (which, on the day I visited, was somewhat below the old "standard" room temperature of 15°C). They are then oven dried at 110°C. The filling and sealing of the ampoules are inspected by three or four representatives of the organizations supplying the membership of the supervisory committee; these inspectors are present at all times during the filling and sealing, although they rotate during the several days of the preparation of a new supply. On the day I visited there were two inspectors from the Hydrographic Department and one from the Meteorological Research Institute.

Following the filling of an ampoule, an inspector checks to see that no droplets have been left in the neck of the ampoule; one such droplet is cause for rejection. The rejected ampoule is emptied (the water is saved for re-use) and recleaned for another try. The neck of an accepted filled ampoule is than flamed off and again inspected. Any sign of solid material in the neck of the ampoule or in the water is cause for rejection, although if evidence of solid material in the neck disappears on tilting water into it and the neck drains clean, the ampoule is considered acceptable.

The ampoules themselves are made of special borosilicate hard glass. The glass is checked by leaching pulverized sample ampoules with distilled water and checking the salinity by potentiometric titration (after some concentration). There is little if any difference from the leachings of the ampoules used by the International Standard Seawater Service.

The chlorinity (salinity) of every 15th ampoule is determined either by a potentiometric titration in the chemical laboratory of the Japan Meteorological Agency or by inductive salinometer in the laboratories of the Hydrographic Division or the Tokai Fisheries Research Institute; titration is considered more accurate and disagreement within a lot of more than 0.003‰ in chlorinity is cause for discarding the lot. (A lot could consist of up to 260 200-ml ampoules or 530 100 ml ampoules, depending on the number rejected.)

Ordinarily Rigosha & Co., Ltd., prepares around 6000 100-ml ampoules (for standardization by titration) and around 2000 200-ml ampoules (for standardization by conductivity) every two years. For standardization against the international standard Rigosha buys some 1000 ampoules of Normal Water each year from the Institute of Oceanographic Sciences in England, where the international Standard Seawater Service is now located, so the (secondary) Japanese Standard Seawater is well tied to the international standard. I am convinced that the Japanese Standard is probably as reliable as the international water, although the product is made in much smaller lots. I was impressed by the inspection procedures, by the records kept, by the comparisons with the international Normal Water, and by the quality of the laboratories finally responsible for the determination of the chlorinity of the standards. I was somewhat surprised by the evident *ad hoc* nature of the operation. Of course valuable space cannot be dedicated to an operation that takes only a few days every two years, so the activities were in two rather cluttered rooms used for other purposes at other times. The ampoule filling and

sealing was carried out in a room some 10 x 12 feet, in which four men were filling the ampoules, one was flame sealing, three inspectors were inspecting, and the manager and I were visiting. But the Japanese are used to small spaces and close proximity.

A few footnotes can be added. The water for the first Japanese Standards was collected by a group of five members of the original committee including Dr. Miyake*, near Iwo Jima, which is one of the Kazan Retto group just west of the Bonin Islands. About 500 liters were collected in May 1941. At first, the chlorinity of this first batch of water was determined using the usual Knudsen silver nitrate titration. Later, the chlorinity was determined using a potentiometric titration combined with weight volumetry. Apparently this was the first use of this highly precise method in the preparation of standard seawater; the method was later adopted by Frede Hermann of the Standard Seawater Service in Denmark. The original Japanese Standard Water was carefully compared with Copenhagen water using this advanced methodology. At the end of World War II, samples of the Japanese Standard Water were sent to the University of Washington's Department of Oceanography, the Scripps Institution of Oceanography, and Woods Hole Oceanographic Institution for independent comparison with Copenhagen water; the Japanese standard did not differ by more than ± 0.02‰ in chlorinity. In the United States, Woods Hole Oceanographic Institution undertook the preparation and distribution of standard seawater, but they discontinued the practice as soon as Copenhagen water could be obtained again.

Finally, Rigosha & Co., Ltd., is a well known instrument and glassware manufacturer-supplier. They manufacture oceanographic and limnological instruments as well as other testing devices, especially for various aspects of the petroleum industry They regularly build box corers that take a 50 x 50 cm core, and they have plans to build an even larger one. This one will take 70 x 70 cm cores; it will be used by the Metals Mining Agency of Japan and the Geological Survey in manganese module exploration.

*Oceanographers will be interested to know that the group also included Dr. Yasuo Matsudaira, Dr. Hitoshi Tominaga, Dr. Masayoshi Ishibashi, and Dr. Koji Hidaka. Hidaka later founded and was the first director of the Ocean Research Institute of the University of Tokyo.

1977 INTERNATIONAL SYMPOSIUM ON FLOW VISUALIZATION

C. W. McCutchen

The Institute of Space and Aeronautical Science of the University of Tokyo held the first symposium on flow visualization in 1973 This and the subsequent annual symposia have been primarily Japanese meetings until the most recent one. For this year, 1977, the symposium was organized as an international one. It was held October 12-15 at the Kokuritsu Kyoiku Kaikan, Tokyo, under the financial sponsorship of The Japan Society for Promotion of Science. Supporting societies were The Japan Society for Aeronautical and Space Sciences, The Japan Society of Mechanical Engineers, The Japan Society of Civil Engineers, and The Society of Naval Architects of Japan.

Flow visualization is the science or art of marking fluid, or looking at it in special ways so that the flow pattern can be seen. To many people it may come as a surprise that flow visualization is a specialty with a name of its own. Do not fluid dynamicists observe flows as a matter of course? In fact, they don't. Flow visualization is difficult and the science of predicting flow patterns is well developed, especially for streamlined bodies like airplanes. Further, engineers want to know forces, pressures and velocities, which are easy to measure directly. Flow visualization tends to be used only when the ship, airplane, or other device does something unexpected. Then there is a more or less desperate scramble to find out what the fluid is doing wrong.

If flow visualizers are rare in the horny-handed world of engineers so are they also in the arcane circle of Ph.D. candidates. Whereas engineers need immediate results that work tolerably well, Ph.D. candidates need "solid" results, where "solid" means quantitative. Flow visualization is seldom the easiest way to get numbers. What it provides is insights into why the numbers are what they are, and, it tends to be used only when the numbers are coming out wrong.

SOLVING PRACTICAL PROBLEMS

There are exceptions to this general rule. Whereas flow remains attached to a streamlined object almost all the way to its sharp rear end, it breaks away from the surfaces of a blunt object, creating one or more regions of separation in which the fluid eddies about usually in an unsteady fashion. There is no sure way to predict where this separation will occur so the location is often found by flow visualization.

W. H. Hucho and L. J. Janssen of Volkswagenwerk, Wolfburg, Germany, showed how the classic method of painting the surface with thick, pigmented oil could locate where separation occurs on a car. Streak patterns in the oil show the average direction of flow at the surface, though there may be an ambiguity in the sense of the direction, tangential to the streaks. Alternatively wool tufts align themselves with the flow a little distance away from the surface and betray unsteadiness of the flow by wiggling.

Incidentally, similar techniques were treated in several other papers of the symposium. J. Sakagami of Ochanomizu University, Tokyo showed how to use dandelion-like plant seed to make light and responsive tufts. T. Tagori, K. Masunaga, H. Okamoto and M. Suzuki of the University of Tokyo compared the results of tuft, oil film and chemical staining methods when used on the same flow patterns. (Substantial differences were found.)

Smoke streamers are also used at Volkswagenwerk A. G. This technique can give an overall picture of flow round a car. Each streamer marks fluid that has passed close to a particular spot, the smoke emitting nozzle. In

the trade they are called streaklines and are identical with streamlines if the flow is steady. Once a region of separation is found, Hucho and Janssen display its shape by filling it with smoke injected directly into the region. Long exposure photographs of helium-filled soap bubbles reveal the unsteady flow within separation bubbles showing, for example, how dirt-laden air from the road reaches the rear window. The rate of dirt deposition can be measured to test the dirt stopping effectiveness of changes in shape, or of flow control devices. Even the flow of rainwater on the body can be mapped and modified to advantage.

T. Imaizumi, S. Muto and Y. Yoshida of the Japan Automobile Research Institute, Ibaraki, described a simple smoke generating wand, and its use in revealing flow both outside and inside regions of separated flow.

Separation can occur in ducts. Y. Shiina, T. Takizuka and Y. Okamoto of the Japan Atomic Energy Research Institute, Ibaraki-ken, used aluminum pigment to make streaklines on the surface of oil flowing in straight and tapered channels with turbulence promoters of various shapes next to the walls. The flow was most easily rendered turbulent in a diverging channel.

M. Akiyama, M. Suzuki and I. Nishiwaki of Utsunomiya University used tracer particles and tufts to observe ventilating flows in a model room and, with a dye-dilation method, measured how long it took to change the fluid in the room.

M. Obata, S. Miyao K. Kurata and K. Kusakari of Ishikawajima-Harima Heavy Industries Co. Ltd., Tokyo, used tufts to map the airflow in a model of a steam boiler, and found that a small design change would largely eliminate a region of flow separation.

Whereas most experimenters want tracer particles to follow the flow as exactly as possible, A. R. Rao, V. Ganesan, R. Natarajan, K. V. Gopalakrishnan, and B. S. Murthy of the Indian Institute of Technology, Madras, were interested in the effect of swirling air on droplets projected by a swirl-generating nozzle, droplets too large to follow the air perfectly and too small to ignore it. When the liquid flow was low the air had a marked effect. When it was high the liquid jet, in effect, created its own breeze and was little influenced by the impressed air swirl.

THE DELTA WING

In delta wing aircraft, except at low angles of attack, the flow separates at the leading as well as the trailing edges and forms a vortex over each wing. At present, this flow cannot be accurately computed especially when an instability of the vortices called "bursting" occurs. H. Werlé of the Office National d'Etudes et de Recherches Aerospatiales (ONERA), Chatillion, France, showed how the vortices can be revealed in a water tunnel, both with dye steamers and by using small air bubbles as flow markers.

Flow separation may also occur on the portion of the fuselage extending forward of the wing. The location of this separation cannot be accurately predicted and may not be the same on the model as on the full sized aircraft because the model tests are at a much lower Reynolds number.

SUPERSONIC FLOW

Supersonic, and especially transonic flows (below the speed of sound in some places, above in others) are difficult to compute. Further, supersonic flow can separate even from well-streamlined bodies because a pressure rise can propagate upstream in the deep subsonic part of the boundary layer and wedge the flow away from the surface. Because this separation influences the flow pattern, which in turn modifies the boundary layer, prediction becomes difficult and uncertain. As a consequence, high speed aerodynamicists often use flow visualization.

C. Veret, M. Philbert, J. Surget and G. Fertin, also of ONERA, gave examples of shadowgraph and schlieren methods applied to aircraft models, wing sections, and turbomachinery and mentioned the virtues of holographic interferometry (of which more later). Shadowgraphs and schlieren make visible the second and first derivatives, respectively, of the refractive index transverse to the light path and thus reveal variations in the density of the fluid.

Whether or not flow will separate from a surface depends on conditions in the boundary layer which is so thin that ordinary velocity measurements cannot easily be done within it.

K. Bracht and W. Merzkirch of Ruhr University, Bochum, Germany, used schlieren photographs of a shock tube boundary layer to see where it changed from laminar to turbulent and showed that, at the same place, the effective thermal conductivity of the boundary layer rose.

R. H. Page and C. E. G. Przirembel of Rutgers University illustrated various uses of schlieren and color schlieren, and along with D. E. Wolf of Somerset County College, North Branch, New Jersey, used color schlieren, shadowgraphs, and the shallow water-wave shock-wave analogy to investigate the resonance tube or Hartmann whistle.

TWO PHASE FLOW

F. Mayinger, H. J. Viecenz and H. Langner of the Technical University of Hannover observed (by taking high speed movies of bubbles and drops) "the mutual influence of vapor and liquid in a boiling two phase flow," as might occur in a nuclear reactor accident.

M. Saita, and M. Kawamata of Ibaraki University and R. Yamamoto of Nuclear Fuel Development Corporation, Ibaraki, cinephotographed events downstream of a fast-closing valve that abruptly stopped the water flow in a pipe and recorded how the repeated cavitation they observed was timed relative to the pressure spikes of the consequent water hammer.

J. W. Hoyt and J. J. Taylor of the Naval Ocean Systems Center, San Diego, California, photographed cavitation bubbles formed in the shear layer at the boundary of a jet. With a camera that compensated for the motion of the flow so as to hold its image stationary on the film, they made two exposures slightly separated in time to show how the cavitation bubbles grew. Adding drag-reducing polymer to the water made cavitation harder to provoke but increased the size and smoothness of the bubbles once they formed. This might, they suggested, explain why drag-reducing polymers increase cavitation damage.

J. M. Dewey and D. J. McMillin of the University of Victoria, B. C., Canada, used shadowgraphs and smoke to investigate the shock waves caused by large explosions, and these plus schlieren to look at shock waves in a shock tube.

SHIPS IN WAVES

Measuring how a ship model responds to waves of different frequencies is a long job if single frequencies are applied one after the other. But a short burst of waves contains all frequencies, so the response of the ship to different frequencies can be obtained by analysis of the model's response to a burst. If the frequency of the wave generator is made to decrease during the burst, the later waves go faster than the earlier ones and catch up to them, making a disturbance of short duration at a point far enough from the wave generator so that reflections from model to generator and back do not arrive until the model's response has been safely measured.

It is important that the wave striking the model has the profile it is supposed to have. T. Hirayama of Yokahama National University, M. Nagai of Mitsubishi Heavy Industries, Yokahama, and I. Ueno of Mitsui Ocean

Development and Engineering Co., Ltd., Tokyo, used a silhouette-by-low-angle reflection method to reveal the shape of the concentrated waves and compared it with theoretical predictions.

SCHOLARS' PROBLEMS

Flow visualization is used to expand the knowledge of fluid dynamics as well as for trouble shooting in practical problems. Y. Oshima and S. Asaka of Ochanomizu University, Tokyo, fired well-standardized smoke rings on parallel courses, or at each other at various angles, and cinephotographed the results. Rings colliding head on at high speed broke up in an interesting fashion.

K. C. Cheng of the University of Alberta, Edmondton, Alberta, Canada, J. Nakayama of Fukushima Technical College and M. Akiyama of Utsunomiya University used dye to investigate secondary flow in thin, rectangular-sectioned ducts bent about an axis parallel to the longer side of the rectangle.

H. Murai and A. Ihara of Tohoku University, Sendai, used cavitation in the wake of a sphere to locate the regions of low pressure. Cavitation bubbles form primarily in vortex cores and are held there by centripetal buoyancy forces. Murai and Ihara deduced the vortex structure of the wake at various Reynolds numbers.

The Kármán vortex sheet is interesting to theorists because the position of flow separation varies cyclically in response to the flow that in turn depends on the separation. A. Okajima, K. Sugitani, and T. Mizota of Kyushu University, Fukuoka, used aluminum dust on a water surface to reveal the vortex-shedding by a rectangular cylinder, both with the cylinder held stationary and with it oscillating transversely. They compared the results with computed flow patterns.

S. L. Gai of the Indian Institute of Technology, Bombay, used smoke to delineate the separation bubble formed against an upstream-facing step and recorded the length of the bubble as a function of the height of the step and the thickness of the boundary layer.

TURBULENCE

Turbulence is the biggest mystery in fluid dynamics. The more measurements that are made of the properties of turbulent flows, the pressure fluctuations, velocity fluctuations, correlations between velocities at different places, etc., the more complex the phenomenon appears to be. So people visualize turbulent flows in various ways, hoping for a view that will suggest a new insight.

A paper by R. S. Brodkey of Ohio State University presented by W. J. Yang of the University of Michigan, discussed in a general way the problems of viewing turbulent flow with special attention to stereo views for revealing the third dimension.

To study fully-developed turbulent flow it is necessary to mark the fluid after it has become turbulent. O. Scrivener, C. Berner and P. Muntzer of the Institut de Mecanique des Fluides, Strasbourg, France, injected fluorescent dye through the wall of a pipe to visualize turbulent flow in both Newtonian fluid and fluid made non-Newtonian by drag-reducing polymer. They measured instantaneous fluid velocities near the wall by photographing the dotted streaks made by stroboscopically illuminated particles. Farther from the wall they used laser Doppler interferometry.

T. Utami and T. Ueno of Kyoto University used hydrogen bubbles to reveal turbulent flow in a model river. The bubbles were made by electrolysing the water at the surface of a fine wire stretched transversely within the model. The current was in brief, separated pulses so as to generate "time lines" of bubbles, i.e., lines of bubbles marking what had at one time been straight lines in the fluid. Flow at the water surface was followed by photographing floating paper punchings.

SMOKE WIRE

Turbulent air can be marked with a smoke wire. Oil, spread along a wire, gathers into fairly evenly spaced droplets under the urging of a capillary instability. Warming the wire with an electric current vaporizes the droplets, and the vapor condenses to form streaklines of oil fog. N. Kasagi, M. Hirata and S. Yokobori of the University of Tokyo used the smoke wire in a turbulent boundary layer and correlated the smoke wire pictures with the simultaneous output of a hot wire anemometer in the boundary layer.

K. Torii of Yokohama National University used a short, high-current pulse through the smoke wire to vaporize all the oil in a short time, making his streak lines short enough to be used like particles for indicating flow velocity. He measured the velocity profile of laminar and turbulent boundary layers and the velocity profile aft of a sphere. Using continuous heating with an abrupt start up he showed the velocity deficit in the Kármán vortex street behind a cylinder. The short pulse and the abrupt start up each provide information that continuous smoke does not.

H. M. Nagib of Illinois Institute of Technology, Chicago, described convenient methods for charging smoke wires with oil and showed comparisons of instantaneous and flow-averaging photographic exposures of the flow in front of a block on or just above the wind tunnel floor. The averaged patterns show a regularity that the instantaneous pictures might seem to deny.

OSCILLATING FLOW

In pure oscillating flow there is no net flow in any direction, so markers must be produced on the spot, otherwise they will never reach it. H. Yamada of Nagoya Institute of Technology used the smoke wire with rapid turn-on to examine the boundary layer above an oscillating plate, also oscillating flow in a rectangular channel, and the start up of oscillating flow in a rectangular channel.

M. Hino of Tokyo Institute of Technology and H. Fujisaki of the Bureau of Ports and Harbors' Yokohama office investigated the secondary flow caused by oscillating a wavy tank floor horizontally under glycerine. To their surprise, the glycerine rendered its own flow visible. Wherever it had been severely sheared, its refractive index was changed and did not immediately return to normal. The layers that had been sheared against the tank bottom entered the secondary flow and revealed its pattern.

Hino and Fujisaki did not know why this retractive index change occurred. There is a previous account of the phenomenon by W. W. Hagerty who used it to visualize Taylor vortices in Couette flow.* Hagerty did not know what caused it either.

S. Taneda, N. Hanji and M. Tatsuno of Kyushu University, Fukuoka, have a different method of marking liquid that has been near a surface When positive current is passed from a metal surface into tap water, a "smoke" of very fine particles is produced near the surface. They used the method to show the Kármán vortex street, also the flows generated by rotatory oscillations of a circular cylinder, by translational oscillations of an elliptic cylinder and by the impulsive starting into motion of a cylinder and a plate.

My own stratified fluid method also marks fluid that has been near an object. There is a temperature jump where the waters meet that have gone around opposite sides of the object. This jump is visible in shadowgraphic projection. I illustrated the method with a motion picture of fish wakes.

*W. W. Hagerty. Use of an optical property of glycerine-water solutions to study viscous fluid-flow problems. Journal of Applied Mechanics *17*, 54-58 (1950). (Bound with Vol. 72 of the Transactions of the American Society of Mechanical Engineers.)

NOVEL MARKERS

No one technique of flow visualization solves every problem, and few solve any problem very well. Many papers explored the virtues and limitations of current methods. Several suggested improvements.

T. J. Mueller read a paper by O. M. Griffin and S. E. Ramberg of the Naval Research Laboratory, Washington, D.C., which said that a fog of di (2-ethylhexyl) pthalate droplets can be used in place of conventional smokes, which are toxic and corrosive.

R. Conrad, B. Krause and G. Wortberg of the Technische Hochschule, Aachen, Germany, used the familiar vapor screen method, but with illumination along rather than across the flow, to make visible the shockwaves in a supersonic jet. Here, increased air density is revealed by an increase in density of the minute water droplets that condensed out of wet air when it expanded in forming the supersonic jet.

T. J. Mueller and V. P. Goddard of the University of Notre Dame described smoke tunnel experiments of the late F. N. M. Brown and showed that usable smoke streaklines could be produced in a supersonic wind tunnel. A problem arises because a smoke tunnel cannot easily recirculate its air. Except on dry winter days, ambient air at South Bend, Indiana, is wet enough so that the condensation mentioned above obscures the smoke trails. This should not be an insuperable problem. Shadowgraph and schlieren methods more easily avoid it but give only indirect information about the flow pattern. Perhaps the time is ripe for the supersonic smoke tunnel.

V. Delitzsch and D. W. Schmidt of the Max Planck Institut-für-Strömungsforschung, Göttingen, used copper-doped zinc sulfide crystals in plastic foam to give phosphorescent markers with the same density as water. These were either excited with a single laser flash and observed with an image amplifier and electronic camera as their brightness decayed or they were illuminated continuously and observed by their fluorescence with an electronic camera.

N. Nakatani, Y. Ohmi, and T. Yamada of Osaka University used crossed beams from two, pulsed nitrogen lasers to excite small, phosphorescent particles in a cross-shaped volume of fluid. The subsequent motion and deformation of the cross was observed by viewing the phosphorescent light with an image amplifier and electronic camera as the cross was swept through a turbulence amplifier.

In a brief, unscheduled talk R. L. Hummel of Toronto University told how kerosene can be loaded with a solute that turns blue on exposure to ultraviolet light. An ultraviolet laser flash makes a straight blue line in the fluid (a time line), whose subsequent motion and deformation can be recorded by ordinary photography. He notes in a leaflet that making two intersecting lines allows the velocity to be measured in three dimensions.

SPARKS

Air can be marked by an electric spark that leaves an ionized path that drifts along with the wind and whose subsequent position and shape is revealed by later sparks which follow the ionized path.

There are infidelities. Later sparks tend to be straighter than they ought. Diffusion smooths any corners in the path and the sparks take advantage of the widening of the path to follow the inside of the bends. The spark path is hotter than the surrounding gas and rises in a gravitational or acceleration field. T. Asanuma of Tokai University, Hiratsuka, Y. Tanida of the University of Tokyo and K. Kurihara of Metropolitan College of Aeronautical Engineering, Tokyo, measured these effects.

K. Matsuo, T. Ikui, Y. Yamamoto and T. Setoguchi of Kyushu University, Fukuoka, used spark traces to measure flow velocities in a shock tube comparing the results with theoretical predictions and with velocities deduced from pressure measurements.

The initial spark is crooked in air at atmospheric pressure. This is not a disadvantage if the wiggles can be recognized in subsequent sparks because each wiggle is in effect a point and one learns the velocity of the flow in two dimensions, or three if stereo views are available. Y. Nakayama, S. Okitsu, K. Aoki, and H. Ohta of Tokai University, Kanagawa, learn the flow direction in a different way. They put into the gas flow small particles that become incandescent in the spark and leave short streaks on the photographic film.

HYDROGEN BUBBLES AGAIN

In the hydrogen bubble method the smaller the bubbles are, the slower they rise in the water. T. Matsui and H. Nagata of Gifu University and H. Yasuda of Pacific Industries Co., Ltd., studied the conditions for making fine bubbles.

Because even coarse bubbles are too small to be resolved photographically, the velocity parallel to the lines and bubbles cannot be determined. So the authors used a cross of wires, like R. L. Hummel's intersecting laser beams, to generate two intersecting sets of time lines.

Particles used to mark fluid should neither sink nor rise in a gravitational or acceleration field. Instead of using helium-filled soap bubbles of neutral buoyancy, as Hucho and Jannsen did for tracking air flows, one can emulate the milkweed and use feathery tracers. J. Sakagami told how to make light, fluffy particles of metaldehyde which sink in air at less than 1 cm/sec.

HOLOGRAPHY

Holography begins to find uses in flow visualization. It can get the same effect as interferometry without the need for large windows, mirrors or lenses of high optical quality. C. Véret, M. Philbert, J. Surget, and G. Fertin of ONERA described ways in which this is done in high speed aerodynamics: F. Mayinger and U. Steinberner of the Technical University of Hanover, Germany, used it to observe convection in liquids.

In contrast, J. M. Auidor and M Delichatsios of Avco Everett Research Laboratory, Inc., Everett, Massachusetts, used a classical Mach Zehnder interferometer to observe convective mixing and compared their results with chemical measurements of the mixing.

J. H. J. van der Meulen of the Netherlands Ship Model Basin, Wageningen, and H. J. Raterink of TNO-TH, Delft, used in-line holography, Gabor's original method, to produce shadowgraph like views of boundary layers whose refractive index had been raised by small additions of salt water. By looking at the reconstructed image with a microscope they could focus on a plane at any desired depth.

M. Yano and I. Fujita of Kobe University used holography in still a different way. Double exposure holograms of a particle-seeded flow give a pattern of optical fringes from which a computer calculates the displacement of the particles between the exposures, and thus the fluid velocity everywhere.

K. Oshima of the University of Tokyo uses a computer to operate on the conventional answers, rather than to get them. Oshima records holographic interferograms of the flow with a TV camera, and then computes various features of the flow, for example, average velocity and velocity fluctuations, getting results almost immediately that most experimenters never get at all.

STREAMING BIREFRINGENCE

Water solutions of Milling Yellow dye become birefringent when sheared, to a degree proportional to the shear rate, under the right conditions. J. T. Pindera of the University of Waterloo showed that the biggest quotient of birefringence by shear rate happily falls at the wavelength where Milling Yellow has its greatest transmission.

M. Horsmann, E. Schmitz, and W. Merzkirch of Ruhr University, Bochum, Germany, observed streaming birefringence in flow over downstream facing steps in a rectangular tube that approximated two dimensional conditions. The birefringence indicated a pattern of shear rate that agreed with theory. This method integrates information from all along the light path. By using scattered light, the authors say, one can learn the state of birefringence in the scattering region only. The observed fringes agreed with patterns predicted by an empirical theory.

T. Arai and H. Hatta of Keio University, Yokohama, cast jelly into a narrow channel partly obstructed by a cylinder. When load was applied to the jelly at one end, so as to try to extrude it from the channel, the jelly became birefringent and exhibited almost the same pattern as had a solution of Milling Yellow flowing slowly through an apparatus of the same shape. I think this illustrates a formal analogy between shear strain rate in a Newtonian material and shear strain in a Hookean material whose Poisson's ratio is 0.5.

Four general lectures described the state of flow visualization around the world. T. Asanuma dealt with Japan, R. Reznicek of VSZ, Prague, dealt with central and Eastern Europe, W. Merzkirch with Western Europe and W. J. Yang with the United States. Differences in emphasis were revealed. Whereas the physical laws that limit technology are the same everywhere the social forces that push it one way or another need not be. In the United States there is a concentration on expensive methods not found elsewhere.

Everyone received a copy of the written proceedings at the beginning of the conference, which helped very much in coping with the inevitable language barriers. All participants owe a great debt to their Japanese hosts for their effort in so skillfully organizing the conference. English-speaking participants are indebted as well to all the Japanese and European authors who struggled with an unfamiliar language.

At the end of the formal part of the conference the flow visualizers were treated to a banquet where the food was Japanese and Western, the music and dancing Japanese. Next day foreign participants were taken on an outing, first to the Fuji Film factory where green packages move down automated production lines and piebald golden carp swim in reclaimed process water outside, and then to the woods and waters of beautiful, mountainous Hakone with glimpses of Fuji in the distance.

A lesson from the conference is that people who need answers use the simplest proven method that will do the job, be it paint, smoke or schlieren. It is Ph.D. candidates and others who have no immediate commercial problem to solve who experiment with new methods. Many of these do not look very practical. Unanswered is the question of what circumstances encourage the innovating of new and practical methods.

The conference gave flow visualizers a much-needed chance to present their work, a chance not always provided by the professional journals which see flow visualization, per se, as a job for tradesmen. I doubt, however, if this or any other conference will make flow visualization into a formal discipline. Flow visualizers are natural subversives who cheat by asking Nature directly what she is doing. I suspect that, while they may gather occasionally and compare notes, their dedication to Nature and the diverseness of their reasons for being flow visualizers will deflect their energies away from professional entrenchment. Would one prefer it otherwise?

JAPANESE MARINE LABORATORIES

Aubrey Gorbman

As an island nation, Japan devotes considerable attention and funding to its academic and mission-oriented (e.g., fisheries) seaside laboratories. In this country about as large as California there are nineteen marine and three freshwater teaching-research laboratories listed in a directory issued in 1975 by the Council of Japanese National Marine and Inland Water Biological Stations. In addition, there are numerous fisheries laboratories whose missions vary from specific applied projects to general research. My own experience over the past twenty-one years, in various visits to Japan, has been in the academic, university-related marine laboratories. On a recent trip to Japan I was able to see nine of the nineteen, some of them for the first time.

The most northerly of the nine is the Sado Marine Biological Station in the Japan Sea, a two-hour ferry, plus 1.5-hour bus trip from Niigata. Specialized equipment is not available, but the laboratory is most useful as a base for collecting the varied marine organisms of the region. The Director, Professor Yoshiharu Honma, is a good systematist, but his reputation is primarily in the morphology of lower vertebrate endocrine structures.

The oldest and most celebrated marine laboratory in Japan is the one at Misaki. Its main building, a two-story brick structure, has changed little over the years, and its use has been adapted largely to the needs of the major "permanent" or most frequent investigators who located their research at Misaki. At present it contains considerable specialized biochemical equipment and an electron microscope since its last Director, Professor Hideshi Kobayashi, has worked there for more than ten years, along with a group of graduate students and visiting scientists. The fauna in such a place so near Tokyo, and overrun every weekend by tourists from the city, cannot be very remarkable. However, Kobayashi continues to work there, and nearness to Tokyo and the aura of its history still attract scientific visitors to the Misaki laboratory. A modern, new dormitory has just been completed there and this should make a biologist's hegira to Misaki still a pleasant experience. As a former Columbia University Professor, I take pleasure in periodically checking on the old dormitory built about 70 years ago with funds supplied personally by Professor Bashford, Dean of Columbia. It is still in use.

A stop worth mentioning in this context is one I made at the Tokyo University Faculty of Fisheries laboratory at Hamamatsu, on the coast between Tokyo and Nagoya. This is an excellent basic research laboratory if fish are your study material and foreign scientists come there for stages of study. The Hamamatsu area is of particular interest since it is a center for aquaculture of eels and a prized smaller fish, the *Ayu.* The developing aquaculture industry is seen to best advantage in the Hamamatsu area.

The Sugashima Marine Biological Station is on an island just off Toba, a tourist-oriented town south of Nagoya. It has a well-equipped new concrete laboratory building and also a new dormitory, both well-conceived and planned by the former Director, Masao Sugiyama. The newly arrived Director, Hidemi Sata, a cytologist, was sixteen years at Cornell and Pennsylvania. The focus of almost all research at Sugashima is the sea urchin, its development, cytology, and taxonomy. The island location makes for a certain amount of adventure in getting to this laboratory from Toba. When original arrangements went afoul, for example, my clearly insufficient Japanese got me on to a "ferry" which left me and my wife, with no recourse, at the wrong place, a tiny fishing village on the same island. The telephone partially straightened things out, and after a night in a very small inn, we were rescued to the proper port.

Something should be said here about the ubiquitous boat that forms the basis for the working fleets at most of these laboratories, a long (25 to 35 feet) narrow wooden hull with a prolonged sharp bow that extends

far forward of the water line. While this makes the boat rather "sea-kindly" in the ever-present chop in these waters, it offers little or no shelter from spray or the elements. Power is supplied generally by a small diesel (under 10 h.p. Yanmar or Yamaha) located astern of a one-man shelter amidships. At Sugashima, apparently in a fiscal year-end budgetary splurge, they had purchased a 19-foot fiberglass cabin runabout three years ago and powered it with an 85 h.p. Johnson outboard engine. The gasoline consumption of this boat (6 to 7 gal./hr.) so shocked them in the face of current gasoline shortages, that it has been sitting dry in a cradle for two years now. When I saw it, the uncovered engine and hull obviously were unloved and were being permitted to go the way of all things sitting on the beach.

In this southward progression, the Seto Marine Biological Laboratory at Shirahama was the first of the marine stations in the coral belt. It is close to the southernmost point of Honshu Island and the warm Kuroshio current is just offshore. Though not rich, the fauna and flora are extremely varied because of the transitional characters of the available habitats. The laboratory has had a distinguished history, but it is not set up for any kind of experimental research. Its focus is on systematics and ecology. About eight years ago, the now retired Director Takashi Tokioka had the effrontery to successfully challenge and defeat the construction of a large tourist hotel on a nearby small island and then to request the federal government to buy the island and declare it a natural preserve. A small laboratory-residence has been built on it. We visited the island, nimbly jumping from the attenuated bow of the 19-foot "Obelia" to a rock on shore, there being no moorage at the place.

The outstanding feature of the Seto laboratory is its excellent library and its "Publications of the Seto Marine Biological Laboratory." The natural beauty of the surroundings, which abound in spectacular views of the convoluted rocky coastline and sea, and the library make this a great place for the systematist to come and write.

The Tamano Marine Laboratory of Okayama University is located about 20 miles south of the university and can be reached by bus from nearby Uno which has a railroad connection to Okayama. It is a relatively small laboratory and essentially a one-man operation. Professor Masao Yoshida, the Director, is a versatile and eminent biologist, interested in the development, fine structure and physiology of photoreceptive organs and tissues. His program, which involves several assistants and graduate students, occupies virtually the entire facility. However, plans are fairly well advanced for construction of a larger modern laboratory to replace the present one at a more distant point, but more convenient to transport by train.

Incidentally, we visited a federal government operated fisheries facility at Uno, only a few kilometers from the Tamano laboratory. This is worth knowing about since the function of the facility is to raise large numbers of young crabs and shrimp, as well as fish (sea-bream) which are released locally to enrich the catches of commercial and amateur fishermen. Thus, an abundant supply of crustacean larvae (nauplius, cypris, zooea, etc.) as well as fish embryos is available to researchers at the Tamano laboratory.

Hiroshima University has established its marine laboratory on Mukaishima Island just offshore of the city of Onomichi, about 40 miles from Hiroshima. Its Director, Professor Akihiko Inaba, a malacologist, has been at this post for more than 20 years and supervised the construction of the present new laboratory in 1973. The Inland Sea locus is very attractive, and the laboratory and dormitory facilities are among the best planned and maintained that I have seen anywhere in Japan. The emphasis is on systematics and ecology of invertebrates. However, an assistant professor is working here on fish chromatophore physiology. A scanning electron microscope is now being installed. Aside from small boats the only working vessel is a 22-foot fiberglass runabout with a 150 h.p. inboard-outboard engine drive. As in the case of a similar boat at Sugashima, this one is used "only about two times a month" because of its fuel consumption (40 liters of gasoline per hour).

Two marine laboratories are maintained on the Amakusa chain of islands, which extend westward toward the Yellow Sea from the mid-part of the western shore of the island of Kyushu. The Aitsu Marine Biological Station (of Kumamoto University) is located in a pretty site on a channel between two islands, and it is about

40 miles (1.5 hours) by car from Kumamoto. A large variety of habitats is available from the laboratory as well as a corresponding variety of faunal types. The main building, constructed in 1971, contains laboratories and dormitories. Its equipment reflects the research interests of the resident staff, Professor R. Hirota, a planktonologist, and T. Yamaguichi, Assistant Professor, who studies the ecology of fiddler crabs and publishes actively. The major part of an older building, which is used for research and for classroom teaching, was constructed hurriedly in 1966. The story told of this building was amusing to us. A visit was scheduled about six months in advance by the Emperor, the Empress and the Crown Prince on October 11, 1966. In honor of the event, it was decided that a new laboratory be built. It was completed ten days before the visit and stocked with examples, appropriately labeled, of all the local fauna and marine flora. At precisely 1300 on October 11 the royal family arrived, and they departed on schedule at 1359, to quote the precise figure.

The Aitsu laboratory has an excellent 40-foot boat with a useful cabin, powered by a 70 h.p. Yanmar diesel engine, to support Hirota's research. As in several other laboratories, a 20-foot fiberglass boat sits in a cradle unused (and usable), its fuel-hungry 60 h.p. outboard motor no longer kept operable.

The Amakusa Marine Biological Laboratory of Kyushu University (Fukuoka) is further out on the inland chain, in a more exposed situation, but time did not permit a visit there.

The southernmost and youngest of Japan's marine laboratories, the Sesoko Marine Laboratory, is on a small island just off (10 minute ferry ride) the west shore of Okinawa, about 45 miles north of the capital city of Naha. It is administered by the University of the Ryukyus where its Director, Dr. Kioshi Yamazato, is Professor of Biology. The University itself was created in 1950 under a U.S. Military Government Directive, and it did not become completely incorporated into the Japanese university system until Okinawa's "reversion" to Japanese civil government was official in 1972.

The main building of the Sesoko laboratory was completed in June 1975. It is a handsome two-story concrete structure containing teaching and research laboratories, offices, and a library below and ten bedrooms above. The laboratories are still under-used, undoubtedly because of the youth of the station and the distance from Japan. They are just being equipped to accommodate some more sophisticated kinds of research. The budgetary climate for the station appears to be good so that its development, to a point, will continue. Beyond that point further development will depend on the degree of use of the facility by local and foreign scientists.

The station deserves to be used, particularly because of its almost unique situation. Although most of the coastline is composed of exposed and protected coral reef and associated fauna and flora, there are available also rocky shores, tidepools and mangrove swamps. Dr. Yamazato is a well trained coral reef biologist who is both appalled and interested in the devastation of the local coral areas by the "crown-of-thorns" starfish, *Acanthaster planci*. He and some of his colleagues have made important studies of the phenomena of killing and (hopefully) regeneration of some of the affected coral reef areas, both in places where efforts were made to remove the starfish as well as untouched areas.

It is worth mentioning that the Sesoko Laboratory has the best accommodations for visitors that we encountered, several attractive three-bedroom (tatami style) cottages, with a western style (hard floor) dining room-study, bathroom, and well-equipped kitchen. There is also an excellent commons room and kitchen attached to the main building for use when student groups are in residence.

A reflection of a favorable budget is the fact that Sesoko's most used boat is a 30-foot Reinell fiberglass vessel with twin gasoline inboard-outboard engines. In this case, the slower diesel-equipped boat is the one that remains in the boat house.

The Sesoko Laboratory's newness, its exceptional location at an uncrowded unpolluted site, its unusual tropical biotic habitats readily available for study, and the relative physical comfort of working there will

certainly attract biologists from Japan and elsewhere and assure further development. At present, systematic, taxonomic and ecologic studies would best be conducted there. Use of the laboratory for experimental and physiological study still would require bringing specialized equipment to the site.

BIOLOGY IN TAIPEI

Aubrey Gorbman

A brief visit to Taiwan quickly impresses on one the fact that this island country, which was violently separated from its parental culture on the adjacent mainland, is valiantly and effectively trying to make its own way in the world. Taiwan's efforts to attain self sufficiency, if not pre-eminence, in certain fields also were impeded for a long time. During this time economic development was skewed toward agrarianism, and cultural development was subordinated to many other things.

We visited four biological study and research institutions in Taipei: the Biology Department of the National Taiwan Normal University, the Zoology Department of the National Taiwan University, the Biomorphics Department of the National Defense Medical College, and the Zoology and Botany Institutes of the Academia Sinica. These are four rather different kinds of institutions, but they have one thing in common: almost all of the teaching and/or research personnel hold a Ph.D. degree from an American University. No Ph.D. degree is offered by a large majority of Taiwanese university science departments, so that the training of each professor must be completed abroad. In certain cultural and historical fields, of course, there is such depth that a Ph.D. program can be organized around it. Another exception is the Biochemistry Department of the National Taiwan University which gives the Ph.D. I met only two unusual Taiwanese professors with Ph.D.'s from a Japanese university.

The National Normal University is located on a two-year old campus in a quiet area at the edge of Taipei. Its mission is to train teachers for the high schools. The Biology Department consists of four professors whose 15-hours per week contact with students probably leaves relatively little time or energy for research. Nevertheless, a considerable number of American instruments were in evidence, and more are "on order." Another sign of determination to establish a research program was the in-progress construction of masonry partitions in about five of the new large student laboratories to create research space. The chairman, Professor C. T. Shih, is a United States trained molecular biologist interested in the analyses of chromosomal histone proteins. Professor C. Y. Wu is another member of this Department who manages to be very active in research. His work focusses on central electroneurophysiology of various motor mechanisms in the cat.

The campus of the nearby National Taiwan University had a vaguely deja-vu quality when I first saw it. This was explained when I learned that it was built during the 1930's (as The Taihoku Imperial University) at about the same time as the Hongo Campus of Tokyo University, which it strongly resembles. After departure of the Japanese in 1945 the reorganized university developed at least in part influenced by cooperative arrangements with several American universities, including California, Michigan State, Notre Dame and Utah.

All graduate students, and many undergraduates, are supported by fellowships, and all are required to participate in a military training program. Of the approximately 13,000 student enrollment, about 1100 undergraduates are science majors (divided among eleven departments). Thus, the 12 professors and associate professors of zoology do not carry a heavy student contact load, although they seem to be listed for teaching a surprisingly large number of separate courses. Only eight graduate students are in the two-year Masters program in zoology. Facilities for research in the old Japanese-built zoology building are rather restricted, but two professors whose laboratories I visited appear to be quite active. These professors were Dorothy Wei King, an embryologist now working on an endocrinological topic, and F. L. Huang who has assigned himself the ambitious task of isolating the protein gonadotropins of fish pituitaries and determining their chemical properties (e.g.,

amino acid sequence). The zoology chairman, C. C. Huang, a geneticist, is enthusiastic about the graduate program. One reason for this enthusiasm is that masters students from his department can be assigned to such well equipped research organizations as the Academia Sinica. This cooperative enlargement of research opportunities for graduate student research is available also to students of the Normal University.

The National Defense Medical Center (NDMC) is a very interesting institution, one in which there is a surprising amount of "pure science" being pursued in addition to the primary purpose of training medical doctors, nurses, dentists and pharmacists. Only in-service military officers and men may apply for admission to the educational program and they are completely supported and receive a stipend while in it. The professors are all high-ranking officers in uniform. Historically, the NDMC dates its origins to the Army Medical College, established in 1902 in Shanghai. It was "evacuated" to Taipei in 1947. The NDMC now consists of 14 academic departments offering regular academic degrees. I visited one of them, the Department of Biomorphics. This department, like four others at the NDMC, contains an institute in which post-doctoral students may remain for advanced study and research. Its chairman, Professor H. M. Liang, is a charming intellectual who has had a hand in organization of several other academic and research biological administrations in Taiwan (e.g., the Academia Sinica) and his influence on development of biological science in Taiwan is quite clear. He operates a meticulously maintained electron microscopy laboratory, used largely for his own current research in pathology. Mrs. Liang (Dr. C. Y. Hsu) teaches in the same department and is involved in a very interesting research program on developmental endocrinology in larval amphibians. Professor and Mrs. Liang received their Ph.D. training in the 1940's from E. V. Cowdry at Washington University, St. Louis. Other professors in the Department of Biomorphics include a comparative anatomist and a neuroanatomist. It was difficult to get any amount of quantitative information about the personnel and programs at the NDMC because, being a military installation, such data are considered classified!

The visit to the Academia Sinica was most rewarding. Like the NDMC the Academia derives historically from an institution of a similar name in mainland China, at Nanking. In Taipei it is composed of ten institutes, representing various branches of science, history, philology, economics, anthropology, etc. The Academia Sinica is the most prestigious academic research organization in Taiwan. Its ongoing research programs are open in some instances to a few graduate students from the universities, but otherwise its mission is purely in research. Administration of the Academia is by a rather top heavy structure of 88 "members" elected for three-year terms and by a Council of 40 life-time appointees of distinguished scientists, something like our National Academy of Science.

The Academia Sinica is located on the outskirts of Taipei on a campus of attractive, functional buildings. My visit was limited to the Institutes of Zoology and Botany, and I concentrated on the endocrinology of Dr. Walter C. M. Wan. The chairman of the Institute of Zoology is Dr. J. C. Su, a learned and urbane man, and his staff consists of 46 "Research Fellows," Associate-, Assistant- and Part-time Research fellows. The programs of research include biochemistry, physiology, cytogenetics, entomology, fisheries, systematics, evolution, marine biology, molecular biology and a variety of other areas. Dr. Y. S. Chow has an active program of development of methods for control of insect pests by use of pheromones and x-ray sterilized males. This has attracted much public attention. Some of the fisheries research is directed toward development of aquacultural techniques. There is also a program for large scale production of "artificial reefs" by placement of concrete box-like forms in inshore waters. These provide shelter for reproduction of various fish species and it is anticipated that they will materially improve the local fish catch.

Thus, much of the research at the Academia Sinica is slanted toward public service and solution of practical problems. Even the rather esoteric endocrine program of Dr. Wan is partly drawn into the practical sphere. He has an active program at the Taiwan Pig Research Institute at Chu-Nan, claimed to be the most efficient producer of pork in the world. Management and synchronization of the reproductive cycle of the pigs, Dr. Wan's area of expertise, is an important element in this undertaking.

The community of Taiwanese biologists, as even this superficial sampling indicates, is developing in numbers and in competence. It is "in touch" with biology in the rest of the world since biologists in Taiwan publish frequently in refereed international journals. This is probably why the quality of education and research in biology in Taiwan far exceeds that found in some much larger countries which have isolated themselves from the world scientific community.

SUPERCONDUCTIVE ELECTRONICS IN JAPAN

T. Van Duzer

The impressions given below result from a two-month stay in Japan which included visits to several institutions engaged in research in superconductive electronics; there were three universities, two government laboratories, one public corporation, and one private company. I also attended two Japanese conferences. Some of the indications of work in progress are from these laboratory visits and conferences, some from encounters at my lectures, and some by word of mouth.

I will start with an approximate history of Japanese work, probably correct to about ± one year. The first Japanese work on Josephson junctions was that of Professor Y. Onodera at Tohoku University in Sendai in 1965. Professor T. Otsuka of their Physics Department may have started then also. In 1967, Dr. Ko Hara started work in the Electrotechnical Laboratory. (He has since moved to Tokyo University.) Also in 1967, Horishi Ohta started some work on Josephson junctions as a Ph.D. student under Professor Shimoda, who was in a different field at Tokyo University. All this early work was apparently aimed mainly at detection applications. Professor Fujio Irie, Kyushu University in Fukuoka, started work in about 1970 with a study of superconductor-coupled junctions. Dr. Akira Nakamura of the Electrotechnical Laboratory entered this work in about 1972 to do e/h measurement and develop a voltage standard. About that same year, Professor Kazuo Fujisawa of Osaka University began work on detection and mixing. In 1973, work on digital applications at Fujitsu Laboratories under the direction of Dr. Toyosaku Isobe began and some device-fabrication studies started at Nippon Telegraph and Telephone Public Corporation under the supervision of Dr. Takahiro Inamura. Professors Takuo Sugano and Sogo Okamura of Tokyo University started their work in 1974 and Professor M. Sugahara changed from other topics in superconductivity to Josephson junctions in 1975. Very recently, perhaps in 1976, Professor Susumu Namba of Osaka University turned part of his attention to the fabrication of Josephson junctions. There are a number of persons who are not heads of research groups that I have left out. I think the above history at least gives the main flow of the development of research in superconductive electronics in Japan.

The following material will give a breakdown of the current work by topic.

FUNDAMENTAL ANALYSIS AND EXPERIMENTS ON JOSEPHSON JUNCTIONS

Subtropic	*Organization*	*Head of Group*
Vortex motion in long junctions	Kyushu University Tohoku University Fujitsu Laboratories	Prof. Fujio Irie Prof. Yutaka Onodera* Dr. Toyosaku Isobe
I-V characteristics	Kyushu University	Prof. Fujio Irie
Potential-valley model	NTT Musashino Laboratory	Dr. Takahiro Inamura
Analog development (ultimately for long junction)	Tokyo University	Prof. Ko Hara
Effect of quasi-particle injection	Tokyo University	Prof. Ko Hara
Analysis of long bridges	Yokohama University	Prof. M. Sugahara

JUNCTION FABRICATION AND TESTING

Subtopic	*Organization*	*Head of Group*
Lead-alloy tunnel junctions	Electrotechnical Laboratory Fujitsu Laboratories NTT Musashino Laboratory	Dr. Akira Nakamura Dr. Toyosaku Isobe Dr. Takahiro Inamura
Pb-Te-Pb junctions	NTT Musashino Laboratory	Dr. Takahiro Inamura
Nb-NbOx-Pb junctions	NTT Musashino Laboratory	Dr. Takahiro Inamura
Metallic bridges by ion implication	Osaka University	Prof. Susumu Namba
Nb microbridges	Osaka University	Prof. Y. Inuishi
Encapsulated point contact	Osaka University	Prof. Kazuo Fujisawa

DIGITAL CIRCUITS

Subtopic	*Organization*	*Head of Group*
Single flux-quantum cells and shift registers	NTT Musashino Laboratory Fujitsu Laboratories	Dr. Takahiro Inamura Dr. Toyosaku Isobe
Logic circuits	Fujitsu Laboratories Tohoku University*	Dr. Toyosaku Isobe Prof. Yutaka Onodera*
Coplanar two-junction quantum interference devices	Tokyo University	Prof. Takuo Sugano

MILLIMETER-WAVE DETECTION AND MIXING

Subtopic	*Organization*	*Head of Group*
Mixing at 36 GHz using point contacts and 4 GHz paramp IF amplifier	Electrotechnical Laboratory	Dr. Akira Nakamura
70 GHz mixing-encapsulated Nb point contact	Osaka University	Prof. Kazuo Fujisawa
mm-wave mixing with J-J net	Institute of Physical and Chemical Research	Dr. Hiroshi Ohta
Detection and mixing with J-J net	Tokyo University	Prof. Sogo Okamura

SQUID MAGNETOMETRY AND THERMOMETRY

Subtopic	*Organization*	*Head of Group*
Preparation of 4 GHz SQUID	Electrotechnical Laboratory	Dr. Akira Nakamura
Noise thermometry	Aoyama University* Tokai and Tokyo Universities	Dr. Kimura* Profs. I. Kosuge and H. Nagano

*Works marked with asterisks are uncertain as I did not see them directly or see publications.

Some concluding comments are in order: I was given thoughtful estimate of 70 as the number of persons active in Josephson junction work in the Tokyo area. I think it reasonable to estimate about 7-10 each at Sendai, Osaka, and Fukuoka with a few in miscellaneous places, giving a total of about 100 for Japan. This number includes graduate students. Also, I heard that a company in Japan, Yokogawa Electric Company, plans to offer RF SQUIDs for sale. Finally, there is a book composed of chapters by various Japanese authors on superconductive electronics in preparation with Professor Ko Hara of Tokyo University as the editor. I believe it will be in Japanese. The following (listed in order of occurrence) may be helpful.

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and Instrumentation Physics
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Toyonaka-shi, Osaka 560

Professor Susumu Namba
Department of Electrical Engineering
Osaka University
Kanemachiyama
Toyonaka-shi, Osaka 560

Professor Fujio Irie
Department of Electrical Engineering
Kyushu University
Fukuoka-shi, Fukuoka 812

Professor Yutaka Onodera
Research Institute of Electrical Communications
Tohoku University
Katahira
Sendai-shi, Miyagi-ken 980

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JAPAN BOUYANT FLIGHT ASSOCIATION (JBFA)

Bruce J. McDonald and Seikoh Sakiyama

These writers recently became interested in the activities of the Japan Bouyant Flight Association (JBFA), a nonprofit corporation organized in 1973 in Japan to focus greater government, industrial and public attention on the considerable potential that Lighter-Than-Air (LTA) technology offers, especially in the construction and transportation fields. The full-time staff consisting of the Secretary General, Mr. Kazumasa Iinuma, and some clerical support are located in modest quarters in Tokyo, about fifteen minutes walk from the American Embassy. The membership consists of about one hundred individuals and includes (i) scholars and researchers, (ii) manufacturers, (iii) potential users and (iv) laymen. Categories (i) and (ii) make up about half the membership. The membership is expected to grow as interest develops in LTA technology.

JBFA sponsorship involves about twenty companies including Japan Steel Co., Ltd., Mitsubishi Heavy Industries Co., Ltd., Kawasaki Heavy Industry Co., Ltd., and Nippon Maritime Transportation Company. The sponsors are major companies; however, the financial resources of JBFA seem to be quite modest.

Mr. Iinuma, the Secretary General, has held that position since 1975 when the preceding incumbent, Mr. Sekizo Kondoh, died. Iinuma was previously a science writer for the Asahi Shimbun (the best known, the most widely read) newspaper in Japan. Mr. Iinuma is better known as a writer and public relations specialist than as a scientist, engineer or technologist. He studied about one year in New York at Columbia University.

The Chairman of JBFA is Professor Hidemasa Kimura of Nihon University. In addition to recognition as an academic scholar and researcher, Professor Kimura is well-known in Japan as the designer of the YS 11, a scheduled commercial airline carrier which has been widely used in Japan for many years.

The Vice Chairman of JBFA is Dr. Eizaburo Nishibori, Director of Japan Productivity Center and Adviser of The Japan Standards Association, whose major professional activities have been in the field of chemistry where he is recognized as having developed some new concepts in nuclear reactor design. He has been involved in many pioneering activities and is well known as the Chairman of the Japan Mountain Climbing Association and for his participation years ago in the first Antarctic expedition following WWII.

In seeking to stimulate increased use and development of LTA vehicle technology, JBFA has focused on such possibilities as island-to-island transportation (up to two hundred miles), delivery to remote construction sites, and delivery/installation of prefabricated units. JBFA activities have also included fostering about four public meetings per year, each concerned with some aspect of LTA technology. One of these meetings is an annual symposium which summarized developments in the field. Proceedings of two of these symposia have been published (in Japanese) and a third one is due to be released in the near future. Other reports are prepared on LTA topics of current interest and published either in Japan or internationally, as appropriate. JBFA has received government support to conduct certain surveys of LTA technology and to publish the findings. The most recent of these survey reports is due out in a few months. Finally, JBFA has arranged for the translation into Japanese of LTA articles published in such languages as English and German.

JBFA may have had some impact already in that the Japan Industrial Technology Association, which derives from the Japan Ministry of International Trade and Industry (MITI), formed a team in September 1977 to assess or evaluate the feasibility of using LTA technology for moving heavy equipment. The team is chaired

by Professor Kimura, the JBFA Chairman. Other team members include Akira Higashi (University of Tokyo), Yoshinori Oka (Mitsubishi Heavy Industries Co., Ltd.), Yoshinori Sakai (Kawasaki Heavy Industry Co., Ltd.), Kazumasa Iinuma (JBFA), Motohisa Komatsu (Toshiba Co., Ltd.) and Bunnosuke Wada (Nitsu Co., Ltd.). Of these, Komatsu and Wada represent user interests on the team, while Oka and Sakai represent manufacturer's interests.

41ST SESSION OF INTERNATIONAL STATISTICAL INSTITUTE IN NEW DELHI

Bruce J. McDonald

The International Statistical Institute (ISI) evolved in the 1800's as recognition developed that national differences could be reduced and common human interests could be increased through better understanding of the relevant statistics. This 41st Session of ISI held 5-15 December 1977 in New Delhi was the second session held in India, the previous one being in 1951. Held in the meeting rooms of the Vigyan Bhawan, the government's official hall of science, the Session was very well attended with more than eight hundred individuals registered from about seventy countries. Several excellent social functions and many administrative, organizational and small, special interest meetings were included in the Session. The encouragement ISI has given in recent years to participation by academic and research statisticians seemed to have elevated the technical content of many of the thirty Invited Paper meetings and the fifteen Contributed Paper meetings which spanned the Session. Together the Invited and Contributed Papers numbered over two hundred and fifty. They concerned such topics as spatial statistics, sample surveys, education and training of statisticians, statistical ecology, inference, point processes, design of experiments, population genetics, stochastic processes, demography and biomedical statistics. A few of the papers are discussed briefly below.

One of the noteworthy events of the Session was the inaugural meeting of the International Association for Statistical Computing (IASC). This event marked the culmination of efforts begun more than a decade ago to strengthen the interactions between professionals in the statistical and computing disciplines. IASC is now chartered to pursue this important mission on the international scene.

Several other meetings were satellited around the ISI Session. These included a meeting of the Institute of Mathematical Statistics, a Seminar on statistical problems arising out of the World Fertility Survey, and a Conference on Optimization Methods in Statistics.

Peter A. W. Lewis of the U.S. Naval Postgraduate School in Monterey, California, presented a paper written jointly with A. S. Shelder of the IBM Research Laboratory in San Jose. Entitled "Analysis and Modelling of Point Processes in Computer Systems," the paper is a significant contribution to an important larger effort aimed at putting a sound methodological foundation under portions of the data gathering and analysis activities which are carried out so frequently these days in order to better design, operate and/or understand modern computer systems. When such practical problems as those in the analysis of computer systems are formulated in the framework of mathematical statistics, they sometimes take the form of problems which can be solved by application of existing statistical methodology. Alternatively, they may constitute new, unsolved statistical problems and they often suggest new approaches or new research areas. In this context, the paper used both univariate and multivariate point processes to model such practical phenomena as (1) occurrences of system failure, (2) arrivals of requests to a storage subsystem, and (3) occurrences of exceptions in a system having hierarchical storage. Analyses which spoke to such matters as computer reliability and computer performance evaluation were considered. Many connections with already published research were indicated and an extensive set of references was given. Some techniques for using point process methods to cope with violations of the usual stationarity assumption were presented, as were some cautions to observe when using time series analysis methods to detect level switching phenomena.

The paper was discussed favorably by several of those who heard it. Professor David Cox of Imperial College noted that many of the general reasons for using point processes were met by the content of this paper,

specifically (1) to gain insight, (2) for forecasting and control, (3) to get models for simulation and synthetic data generation and (4) for empirical explanation. This writer felt that the paper was most useful in its relation to many of the other recent publications of Lewis and his associates. In view of the broad interest in the computer systems applications and of the complex methodology involved, it may be time to start thinking about a book to collect, condense, interpret and communicate this major contribution which the statistical profession is making toward better understanding.

Another interesting paper was given by O. Macchi of the Laboratoire des Signaux et Systemes, Centre National de la Recherche Scientific, 91190 GIF/YVETTE, France. In the paper, titled "Stochastic Point Processes in Pure and Applied Physics," Macchi briefly noted that Indian scientists first used point processes in physics. She also noted the basic 1950's work on photon statistics wherein point process theory was used to develop an experimental demonstration that the photo-detection process is non-Poisson under certain conditions. The main thrust of Macchi's paper is based on three properties of coincidence densities (i.e. product density functions): (1) regular point processes can be conveniently characterized in terms of coincidence densities, (2) under a hypothesis of complete regularity, exclusion probability densities can be analytically related to coincidence densities and (3) there is a constructive procedure for using coincidence densities to build up new point processes. The paper examines the cases of bosons and fermions in substantial detail, deriving expressions for their coincidence densities and exclusion probability densities, discussing the validity of the associated point processes and relating the analysis to the bunching effect of the bosons and antibunching effects of the fermions, which effects have been widely studied both theoretically and experimentally. Finally Macchi examines the use of point process models in such optical communication problems as (1) detection of a light pulse, (2) estimation of chaotic light intensity, and (3) estimation in the presence of background light.

One additional paper which caught this writer's attention was given by J. A. Bather of the University of Sussex and titled "On The Sequential Construction of An Optimal Age Replacement Policy." The context of the paper involves a system component which experiences random failures according to an unknown distribution. Renewals take place either because of such random failures or due to a policy of planned replacements. Costs are associated with renewals and also with random failures. Bather's approach is to develop a sequential procedure which produces consistent estimates of the critical age in the optimal replacement policy and to use these estimates in such a way that the minimum average cost is attained in the long run.

In summary, this writer concludes that the 41st Session was an outstanding meeting. The strong role of the Indian statistical community, both as hosts and participants, was a credit to the memory of the late P. C. Mahalanobis, who did so much to strengthen that community and to find ways to make statistics play an important role in the national affairs of India. With C. R. Rao the incoming ISI President, the strong Indian participation is assured as ISI moves towards its next Session in 1979, in Manila.

KOREA STANDARDS RESEARCH INSTITUTE

Bruce J. McDonald

This writer recently had an opportunity to visit the Korea Standards Research Institute and become acquainted with some of the activities of that vigorous, young organization. Established in 1975 as an autonomous research institute, K-SRI (pronounced "Kay-sree") is the central authority on all Korean standards and fosters the scientific, technological and industrial development of the nation by establishing, maintaining and promulgating the national standards.

The steps leading to the establishment of K-SRI trace back to July 1965 when the United States provided Korea with a set of primary standards as a symbol of cooperation in science and technology. United States participation in this venture has been sustained till the present time and is expected to continue. Among the significant elements of participation are (i) an early feasibility study by GE-TEMPO, (ii) timely funding by U.S. Agency for International Development which provided a firm financial footing in the initial period and which still has a stabilizing influence, and (iii) development of a "sister relationship" between K-SRI and the U.S. National Bureau of Standards.

At present K-SRI is located in temporary quarters in Seoul. Permanent quarters are being prepared in Dae Duk (pronounced "day duck"), the new science city under construction about 100 miles south of Seoul, near Daejon City in Central Korea. The new K-SRI facility will become the core of the Dae Duk R and D complex which is expected to include some eighteen other private and public research and/or academic institutes. The planned K-SRI campus has good balance, appears to be well matched to the nation's current needs and provides adequate space for future expansion. By summer 1978 the main administration building, the first laboratory and four other buildings should be finished and occupied. By 1982 at least six additional buildings should be in service. The formal opening of the new campus is planned for September 1978.

Laying plans which have taken careful account of the current and projected needs of Korea's standards users, K-SRI's President, Dr. Ing Zae-Quan Kim, has earned the confidence of his superiors in the Ministry of Commerce and Industry and of many other responsible authorities in the Korea science and technology community such as Dr. Hyung-Sup Choi, who is the Ministor of Science and Technology. Kim is now filling key positions in the growing Institute. Recruitment is being conducted with emphasis on repatriation of Koreans who have acquired strong academic and professional credentials abroad. Positions already filled include persons with advanced degrees earned in the United States, France and Germany.

In the short term, K-SRI is concentrating on the installation of essential precision reference standards and basic measurement instruments and facilities. The longer term goals include (1) the modernization of the entire national standards system and maintenance of its international traceability, (2) upgrading the precision of the national measurements standards as required to support the current rapid advancement of measurement technology in Korea, (3) establishment of a systematic calibration service for precision measurement instruments and facilities throughout the country, (4) provision of methodological education and training for technicians engaged in metrology practice, and (5) provision of standard reference data and standard reference materials services. It will be satisfying and also very interesting to observe both the short term and long term success of this ambitious young Institute.